Established by BENJAMIN SILLIMAN in 1818.

THE AMERICAN JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS GEO. L. GOODALE, JOHN TROWBRIDGE, H. P. BOWDITCH AND W. G. FARLOW, OF CAMBRIDGE,

PROFESSORS O. C. MARSH, A. E. VERRILL AND H. S WILLIAMS, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA,
PROFESSOR H. A. ROWLAND, OF BALTIMORE,
MR. J. S. DILLER, OF WASHINGTON.

FOURTH SERIES.

VOL. III—[WHOLE NUMBER, CLIII.]

No. 18.—JUNE, 1897.

NEW HAVEN, CONNECTICUT.

1897.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 125 TEMPLE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

BROKEN HILL.

We have lately received a collection purchased for us in New South Wales, that is wonderfully rich in the splendid crystallizations of lead and silver minerals of the Broken Hill mines. The occasional samples that have found their way to Europe have given the locality a name for "fine things," though unfortunately so rare that they have reached but few collectors.

Twir Cerussite! in brilliant white groupings of "V"-shaped twins and also multiple crosses with delicate interlacing of needle-like crystals, suggestive of the forms taken by snow crystals, $1.50 to $5.00. Smaller pieces and microscopic mounts, 25c. to $1.00.

Anglesite in crystals and also a pseudomorph after Galena and Cerussite.

Embolite! Masses of irregular crystals, and as veins in Kaolin. Also a few specimens of a black limonite "gossan" showing isolated crystals of definite form and bright planes. The latter are desirable and pretty examples of a species seldom well crystallized. Low prices, $1.00 to $4.00. Smaller and microscopic, 25c. to 75c.

Iodyrite. Extremely rare. A few specimens showing miscroscopic crystals of characteristic twin types.

Linarite! Handsome groups of small blue crystals of high lustre and rich color, but with a perfection of form unusual to the species. Bright and pretty, $1.00 to $2.50. Mounts of georgeous quality making the best microscopic examples known of this beautiful mineral; 50c. to 75c.

Smithsonite; showy groups of green crystals and in botryoidal masses, $1.00 to $4.00. Microscopic specimens, 50c.

Native Copper in delicate arborescent forms, 15c. to $2.00.

Azurite in lustrous tabular crystals associated with Cerussite. Not so showy as the Arizona product but of different type. Also Pyromorphite, Garnets, Gold Quartz, etc., etc.

FROM SKIPTON CAVES, NEAR BALLARAT, VICTORIA.

Newberyite, a rare species hitherto unrepresented in the museums and great collections of the world. Aggregations of orthorhombic crystals like those figured by Dana, and also tabular forms, 50c. to $1.50 for the best.

Struvite, in small crystals, 25c. each.

☞ *We send minerals on approval.* EXPRESS PAID, *you being at liberty to return anything not wanted. The Australian things are going rapidly. Order early.*

Collections for Teachers, Students, and Prospectors.

LABORATORY MATERIAL. **CRYSTALS.**

Catalogue Free.

Dr. A. E. FOOTE,

WARREN M. FOOTE, Manager.

1317 ARCH STREET,

PHILADELPHIA, PA., U. S. A.

ESTABLISHED 1876.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XLIII.—*Studies in the Cyperaceæ;* by THEO. HOLM. IV. *Dulichium spathaceum* Pers., a morphological and anatomical study.

THE monotypic genus *Dulichium* has quite a large distribution in the eastern part of North America, extending from Nova Scotia as far south as to the tropical Florida. It is a strictly hydrophilous plant, growing socially along rivers or on borders of ponds, in wet moss or in the water itself. But in spite of the very common occurrence of our plant there are, nevertheless, some points of morphological and anatomical interest, which have, so far, escaped the attention of the botanists. Although our plant possesses only a few characters, by which it is readily distinguished from its nearest allies, a general sketch may be of some importance in order to give a more complete idea of its entire organization. It is, altogether, the writer's intention to present in these cyperographical studies a number of details, observed in the various representatives, so as to collect some data, which might facilitate the study of the mutual affinities of the genera and species of this large group of plants.

In regard to the systematic position of *Dulichium* it is generally placed near *Cyperus* and *Kyllinga* on account of the two-ranked bracts of the inflorescence; but it differs from these genera by the presence of bristles in the flower and by the distinctly beaked achenia. It is, also, generally stated that *Dulichium* has only lateral inflorescences in contrast to *Cyperus* and *Kyllinga*, but this statement is, of course, not correct, as shall be demonstrated in the present article.

If we examine the underground part of *Dulichium* we observe a rather long, horizontal rhizome with sympodial ramification and reminding one very much of *Eleocharis palus-*

tris and others. The internodes are distinct and partly covered with rudimentary, sheathing leaves. Relatively strong roots develop above the nodes, especially from the lower surface. Several stems, above-ground, arise from the rhizome and they show a structure very different from what we are accustomed to see in the *Cyperaceæ*, having numerous cylindric and hollow internodes. As we remember the stem, above-ground, of the *Cyperaceæ*, it is generally solid and forms a distinct, often very long scape. Vegetative branches do not commonly develop upon the stem, above-ground, but we have noticed, however, a few cases where a small, horizontally creeping branch had developed from the axil of one of the stem-leaves. Such secondary branches showed the same kind of ramification and structure as the rhizome.

The leaves of *Dulichium* are either reduced to tubular sheaths upon the rhizome and at the base of the stems, or they are normally developed with a linear blade, a short, crescent-shaped ligule and a long tubular sheath.

By considering the inflorescence we find the flowers arranged biseriately in spikes. Each flower is perfect, supported by a scale-like bract, and has commonly eight downwardly barbed bristles, which are a little longer than the style of the ovary. The three stamens have long filaments and reach above the apex of the bristles. The style is papilliferous in its entire length like the two filiform stigmata; the achenium is at maturity oblong, flattened, shortly stipitate, and the remaining style forms a slender beak. By returning to the inflorescence, we have stated above, that the flowers are arranged in from six- to eight-flowered spikes, which again are arranged biseriately along a short rhachis, which is the continuation of a short peduncle, almost entirely inclosed by the sheath of the supporting leaf. The inflorescence consists then of one terminal and about eight lateral spikes, these last being supported by scale-like bracts, but destitute of any prophylla. A prophyllon, clado-prophyllon, is, however, to be observed at the very base of the peduncle; it is very short and tubular with the apex oblique. While this general structure applies to all the lateral inflorescences of *Dulichium*, it also agrees with the terminal one, with but one exception, that no prophyllon is developed at the base of the peduncle, this being the immediate continuation of the main stem itself. By comparing now the inflorescences of our genus with those of *Cyperus*, the difference consists merely in that they are scattered along the stem in *Dulichium*, while in *Cyperus* they are gathered towards the apex of the long scape. In this way the inflorescences in *Cyperus* form like an umbel with the outer (the lowest-situated) borne on longer peduncles than the inner ones, while the terminal inflorescence is almost sessile in the center of the umbel.

The terminal inflorescence in *Dulichium* is, on the contrary, the highest situated and is readily distinguished from the lateral ones by having no prophyllon.

The most important morphological peculiarity in *Dulichium* lies, therefore, in the structure of the stem with its numerous internodes of equal length, a structure which naturally influences the composition of the inflorescence, but in reality only differing from the related genera by the non-development of one of the internodes into a scape.

We will, thereupon, examine the internal structure of our plant, beginning with the foliar organs. The cauline leaves with well-developed blade show a structure which is very much the same, as we know from the literature, to be characteristic of the genus *Carex*. The epidermis of the blade shows a very uniform structure on both faces, the upper and the lower, and it seems to be a marked characteristic of *Dulichium* that hairs are entirely wanting and that epidermal thorns very seldom occur. It is only along the margins and along the keel of the leaf that such thorn-shaped expansions are to be found. The cuticula is rather thin and stomata are only present on the lower surface of the leaf-blade; they are slightly prominent, surrounded by four cells and form generally two longitudinal rows between the mestome-bundles. Concerning the shape and the size of the individual cells, the epidermis does not show anything of interest, except that some of the cells, which lie above the median mestome-bundle, are developed as "bulliform-cells." The peculiar internal cone-shaped projections, which we have recorded in our article upon *Carex Fraseri*, abound in the epidermis of the leaves of *Dulichium*. In regard to the cell-content of the epidermis, we were rather surprised to observe that tannin was present in several of the cells, and we succeeded later on in tracing this matter to various tissues of the leaf, the stem, the rhizome and the root. Antoine Mazel* deserves the credit for being the first author who detected the tannin-reservoirs in the genus *Carex*, a fact that is the more interesting since the *Cyperaceæ* formerly, like the *Gramineæ* and the *Ranunculaceæ*, were considered exceptional in not possessing reservoirs of any kind.

The mesophyll of the leaf consists of about four strata of closely packed palissade-cells on the upper face, while the remaining part of the mesophyll is built up by more or less irregular cells, which surround large lacunes, one between each of the two mestome-bundles. By studying the development of these lacunes in very young leaves, it was observed that they originated from the coalescing of a group of from four

* Mazel Antoine: Etudes d'anatomie comparée sur les organes de végétation dans le genre *Carex*. Genève, 1891. (Reviewed by the writer in the Bot. Gazette, February, 1892.)

to five colorless cells. Very characteristic of the mesophyll are the numerous and large tannin-reservoirs of long, cylindric cells, single or several connected together. These reservoirs are especially abundant just inside the epidermis of the upper face of the leaf, where we have counted no less than fifty reservoirs inside a stratum of about one hundred epidermis-cells. They are, also, quite abundant in the inner part of the mesophyll, around the lacunes, or bordering on the parenchyma sheath of the mestome-bundles. Concerning the general distribution of the mesophyll in the leaf, it appears, on examination of transverse sections, to form isolated groups between the larger mestome-bundles, which are supported, on both faces, by groups of stereome.

The mestome-bundles are all situated in a single plane in the leaf, averaging about twenty-five on each side of the midrib; they represent two forms, according to their size. The largest are the most numerous and differ from the smaller ones by a fuller development of their leptome and hadrome; otherwise the structure is identical for both. There is a parenchyma-sheath of thin-walled and usually colorless cells, inside of which is a constantly closed mestome-sheath,* the cells of which are slightly thickened. This inner sheath, by Schwendener called the mestome-sheath, was first pointed out by this author as characteristic of the *Cyperaceæ*, *Juncaceæ* and a number of *Gramineæ*.

The leptome and the hadrome are not separated from each other by thick-walled mestome-parenchyma, and both are well differentiated in the largest bundles. The hadrome contains generally two pitted ducts and a few ring-vessels. A small lacune is often to be observed above the ring-vessels.

Stereome is not abundant in the leaf, and forms only small groups above and below the larger mestome-bundles, while the smaller bundles are merely supported by this tissue on their hadrome-side; it does not occur as isolated groups excepting in the margins of the blade. The stereome was, in some instances, observed to surround tannin-reservoirs, especially on the superior face of the leaf.

Having now examined the structure of the assimilating leaf, we might in this connection consider the bracts of the inflorescence. There are, as stated above, really two kinds of bracts in the inflorescence of *Dulichium*, viz., those which support the spikes, and those which support the single flowers, but although their shape is somewhat different their internal structure is exactly the same. These bracts show a very firm structure due to the extremely thick-walled epidermis of the dorsal face, which is the only tissue that constitutes the broad, hyaline

* Schwendener S. Die Mestomscheiden der Gramineenblätter, Sitzungsber. k. Akad, Berlin, 1890.

margins of the bracts. No stomata are to be observed and the epidermis does not show any development of the so-called bulliform-cells. Epidermal expansions as thorns were only observed along the margin, and some of the epidermis-cells of the ventral face were found to contain tannin. There are usually only five mestome-bundles, which are very weakly developed, containing merely leptome and no vessels; the mestome-sheath is well-marked and is composed of thick-walled cells. There is only a small quantity of mesophyll in the bracts, and this forms isolated groups between the mestome-bundles, being composed of a few, two or three, layers of closely packed polyedric cells. Only a few tannin-reservoirs were observed in the mesophyll.

A much stronger development is shown to be possessed by the stereome. This tissue shows, however, the same distribution as we have seen in the green leaf, but it attains a more considerable size in the bracts, where it, also, occurs in several isolated groups, viz., on both sides of the midrib and near the margins.

The stem, above-ground, is, as we have shown in the preceding cylindric, hollow and distinctly jointed. It is perfectly smooth, since the epidermis is destitute of any projections. The epidermis shows, altogether, a very uniform structure like we have seen in the leaf, and we find, also, here the internal silicious cones in those cells which cover the stereome. Stomata are present, but rather scarce, forming merely a single row between the ribs on the free part of the internodes.

The green bark, the assimilating part of the stem, does not form any closed ring in *Dulichium*. It consists of closely packed polyedric or roundish cells, and forms, in transverse sections, isolated groups between the outer band of mestome-bundles. It contains only a small number of tannin-reservoirs, which are generally situated close to the large, round lacunes. These lacunes correspond in number and arrangement to the mesophyll, which borders immediately on their exterior side. Inside the ring of lacunes is a rather heavy layer of colorless parenchyma, the cells of which are large and roundish, and in which an inner band of mestome-bundles is imbedded. The center of the internode is occupied by a wide cavity, originated from the breaking down of the central mass of fundamental tissue. The nodes themselves are solid and largely built up of very thick-walled, star-shaped cells, which are conspicuously porose.

The mestome-bundles of the stem form, as stated above, two concentric bands, those of the inner being the largest. They are all collateral, and are surrounded by thin-walled parenchyma-sheaths; the leptome and the hadrome is well differentiated and sometimes separated by a layer of thick-walled mestome-parenchyma.

Stereome is well represented in the stem, where it occurs on the leptome-side of the outer mestome-bundles and on the hadrome-side of the inner ones. In this way it does not form any closed ring neither around the single mestome-bundle nor around any of the two bands of bundles, which, otherwise, seems to be quite common in the stem of the *Cyperaceæ*.

The peduncle, the spike-bearing stem, shows very near the same structure as we have observed in the main stem. There are, however, a few differences to be found, which may be noticed here in connection with the stem-structure, since such structural divergencies between stem and peduncle have not, hitherto, been studied very much. Grevillius,* Laborie† and Trautwein‡ are some of the few authors who have treated this subject, and their studies have shown us many interesting details in regard to the anatomy of the inflorescential axes in a number of plants.

In *Dulichium* the peduncle is strongly flattened in contrast to the cylindric stem, a fact which is due to its tight enclosure in the long leaf-sheath. It shows a relative firm structure in regard to the development of the mechanical tissue, and is solid, not hollow. The epidermis agrees very well with that of the stem, but is armed, however, with a few rows of thorn-shaped expansions along the two lateral margins. The stomata and the interior projections show the same structure and distribution as described above as characteristic of the stem. The bark-parenchyma contains chlorophyll and surrounds large lacunes, which alternate with a corresponding number of mestome-bundles.

These, the bundles, are arranged in a peripheral band; they are surrounded by a thick-walled parenchyma-sheath, and the leptome is often separated from the hadrome by mestome-parenchyma of thick-walled cells. The leptome occupies only a small part of the bundles, while the hadrome is more fully developed with several ring-vessels and generally two large pitted-ducts. The stereome forms large groups around the mestome-bundles. Tannin-reservoirs are, also, present in the peduncle, where they were observed in the bark close to the lacunes, but not in the large, colorless parenchyma, which occupies the center of the peduncle.

This is the general structure of the peduncle underneath the spike-bearing part, the rhachis, and we notice by examining this a certain change in structure, which is, especially, due

* Grevillius, A. I. Anatomiska studier œfver de florala axlarna hos diklina, Fanerogamer, Bihang Kgl. Svenska Vet. Akad. Hdlgr., vol. xvi. Stockholm 1890.

† Laborie, E. Anatomie des axes floraux Revue scientifique, vol. xliv, Paris, 1888.

‡ Trautwein, J. Ueber Anatomie einjähriger Zweige und Blüthenstandsachsen, Inaug. diss, Halle, 1885.

to the biseriate insertion of the flower-bearing spikes. A transverse section of the rhachis shows a change in regard to the outline, from almost flattened to semicylindric, while the minute structure at the same time shows some points of difference. The mestome-bundles have moved farther in towards the central, colorless fundamental tissue, and most of them have lost their outer support of stereomatic tissue. It is only on the concave side of the rhachis that the stereome is well developed so as to form supporting layers for the mestome-bundles. The mesophyll shows the same structure as in the peduncle, and it contains several lacunes of rather irregular size and shape.

Very different from the peduncle and the rhachis in regard to shape and structure is the rhacheola, the axis of the flower-bearing spike. It is broadly winged from the decurrent margins of the bracts and shows a very simple anatomical structure. The epidermis contains tannin in great abundance, and the inner tissue is largely composed of a colorless parenchyma in which two or three small mestome-bundles are imbedded. These are partly surrounded by a single layer of stereome besides by a thick-walled parenchyma-sheath; the elements of the leptome and the hadrome are well differentiated.

Having examined the aerial stem of *Dulichium* with the peduncle, the rhachis and the rhacheola, we will now proceed to the stem under-ground, the rhizome. The entire structure of the rhizome does not show any considerable strength in development, which is evidently due to the fact that the soil in which our plant grows is generally very soft and loose, and does not make any great resistance necessary. The epidermis shows naturally a much more simple structure than we observed in the stem above-ground, being deprived of stomata and epidermal projections. The cell-content is on the other hand not only represented by tannin, but also by large deposits of starch. Inside the epidermis is a broad layer of thin-walled bark-parenchyma, filled with starch, besides that tannin-reservoirs are to be seen in the outermost layers, close to the epidermis. The bark contains only one, but very large lacune, which occupies the greater part of the dorsal, the upper part of the creeping rhizome. The innermost stratum of the bark-parenchyma is differentiated into a completely closed endodermis, which, from the manner in which the cell-walls are thickened, represents a typical U-endodermis. A large, starch-bearing fundamental tissue is to be observed inside the endodermis, and it is here that the mestome-bundles are situated.

These, the mestome-bundles, are all well-devoloped, but are not arranged in any order; they represent two forms, viz, collateral and concentric or, in this case, perihadromatic, since

the leptome is partly surrounded by the hadrome. This form of bundle, the perihadromatic, is not uncommon in monocotyledonous plants, while the perileptomatic type is especially characteristic of the Ferns.

The mestome-bundles, the collateral and the concentric, show a still more advanced development in the rhizome than in the stem above-ground, viz., the hadrome has a greater number of pitted-ducts and the leptome-groups are much larger.

The innermost part of the central cylinder is, as stated above, occupied by a mass of starch-bearing fundamental tissue. The stereome is rather poorly developed in the rhizome and its cells are rather thin-walled. It is here restricted to the mestome-bundles which it partly surrounds, and it seems to be strongest developed on the hadrome side, the inner face of the bundles. Numerous tannin-reservoirs were observed to be scattered around in the groups of this tissue, the stereome.

We have now pointed out the principal anatomical characteristics of the leaf and the stem with their various modifications, such as they are represented in our genus, and we might finally give a brief sketch of the root, although this was not observed to possess any peculiarities so as to be distinguished from that of the majority of the other *Cyperaceæ*. There is, inside the epidermis, a single layer of very thick-walled cells, which form a closed ring around the broad bark-parenchyma, in which a few tannin-reservoirs are to be seen. The bark shows the characteristic tangential collapsing of some of the cells, and its innermost layer is differentiated as an endodermis. The pericambium consists merely of one layer of cells, which are interrupted here and there by the protohadrome. The center of the root is occupied by two very large vessels, which alternate with the corresponding groups of leptome.

Washington, D. C., December, 1896.

EXPLANATION OF FIGURES.

Anatomy of *Dulichium*.

FIGURE 1.—Transverse section of the median part of the leaf-blade, showing the bulliform-cells above the median mestome-bundle. × 320.

FIGURE 2.—Transverse section of epidermis of leaf, showing a silicious cone inside one of the epidermis-cells. × 400.

FIGURE 3.—Tannin-reservoirs in the mesophyll and in the stereome from a transverse section of the leaf-blade, the upper face. The black-painted cells indicate the tannin-reservoirs in this as well as in the other figures. × 240.

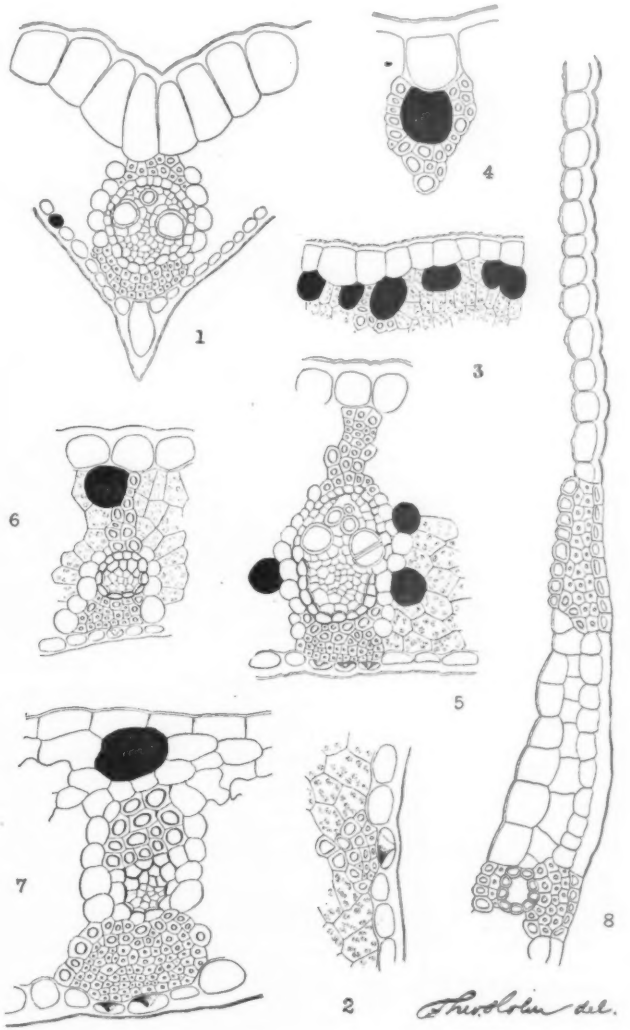
FIGURE 4.—Tannin-reservoir in a group of stereome from the superior face of the leaf-blade. × 400.

FIGURE 5.—A large mestome-bundle from the leaf-blade, transverse section. Three of the epidermis-cells contain cones, and tannin-reservoirs are observable in the mesophyll. × 320.

FIGURE 6.—Transverse section of a small mestome-bundle from the leaf-blade. × 320.

FIGURE 7.—Transverse section of a bract, showing a mestome-bundle, a large group of stereome and a tannin-reservoir. × 320.

FIGURE 8.—Same section, showing the midrib and a part of the margin, which only consists of the dorsal epidermis. × 60.



Art. XLIV.—*Bacteria and the Decomposition of Rocks;* by John C. Branner.

Having had occasion recently to study certain features of rock decomposition, I was frequently told that bacteria were important agents of rock decay. I here indicate as briefly as possible the evidences considered and the conclusions reached in regard to this subject.

The *bacteriaceæ or schizomycetes* of the botanists are a group of the simplest microscopic fungi. Fermentation and putrifactive processes are the results of the growth of certain of these bacteria.*

The discovery that organic decay was a process of bacterial growth seems to have given rise to the idea that this decay extended to minerals and rocks as well. In 1890, Muntz, speaking of decomposed or disintegrated rocks said,† "In applying to rocks in this condition the word *decayed*, which, since the work of M. Pasteur is so clearly explained as *facts connected with the growth of microscopic organisms*, we unconsciously establish between these two orders of ideas a correlation confirmed by the researches mentioned above." The italics are in the original. In this article Muntz speaks of having found bacteria "in the denuded rocks of the Alps, the Pyrenees, the Auvergne, and the Vosges, comprising the most varied mineralogical types: granites, porphyries, gneiss, mica schist, volcanic rocks, limestones, sandstones.† . . . . Often the action of the micro-organisms is not confined to the surface, but extends into the depth of the rock mass. This is the case with the so-called *rotten* rocks of which the particles become disengaged and separate as is often seen in limestones, schists and granites. In decomposed rocks I have always verified the presence of the nitrifying organism."

This statement of Muntz seems to have given rise to the somewhat prevalent idea that rock decay is, like organic decay, a process of bacterial growth. It appears to have been accepted without question, and one finds occasional references to the work of bacteria in rock decay as if it were a fact as well established as their work in organic decay.‡

Accepting the statement of Muntz that bacteria are found

* A. De Bary, Comparative Morphology and Biology of the Fungi, etc.; translated from the German by Garnsey and Balfour, Oxford, 1887. (Contains bibliography.) Duclaux, Chimie biologique, Paris, 1883. Cornil et Babes, Les Bacteries, 2d ed., Paris, 1886. Hueppe, Die Methoden der Bacterienforschung, Wiesbaden, 1885. Writings of Pasteur, Koch, Lankester.

† Comptes Rendus, cx, 1890, 1372.

‡ Robert Warington, U. S. Dept. of Agriculture, Exp. Sta. Bull., No. 8, p. 70; H. W. Wiley, Yearbook of the U. S. Dept. Agriculture, 1895, p. 71.

in decayed rocks, let us inquire into the possibility of their finding conditions favorable to their existence in undecayed ones.

There is a great difference among bacteria with regard to the conditions under which they thrive. For example, those called *ærobiotic* by Pasteur require a large supply of free oxygen, while the *anærobiotic* thrive best when the oxygen is kept from them.

The kind found by Muntz in decayed rocks are what are known as nitrifying bacteria, that is bacteria that reduce nitrogenous matter to nitric acid, or nitric acid to lower forms of oxidation. To most forms organic food is absolutely indispensable, but several authorities have demonstrated that the nitrifying bacteria may live without organic food.* This fact seems at first to place the statement of Muntz beyond question, for if bacteria can live in inorganic media, why can they not live in the rocks? But these bacteria are composed principally of carbon and nitrogen and in order to live they must take up these substances with their nourishment, either from the air or from some other source. It is known that the carbon of the bacteria may be derived from organic sources. De Bary says that "as far as we fully and certainly know, the parasitic mode of life is always indispensable to the complete development of the *facultative saprophytes*," which is understood to mean that organic matter is necessary to that existence.†

Warming, a thoroughly trustworthy authority, definitely states that "*organic carbon* compounds are indispensable for all bacteria (except, as it appears, for the nitrifying organisms), as they can only obtain the necessary supplies of carbon from this source."‡ Note his exception. He also says that "the bacteria are unable to assimilate carbon from the carbonic acid of the air." Berthelot says that the carbon and hydrogen of the atmosphere does not appear to be capable of supporting the life of the nitrogen-fixing bacteria, and that they are nourished by substances furnished by higher organisms.§

Experiments by Monro in 1886,‖ by Frankland in 1885–6 and by Winogradsky in 1890¶ have demonstrated that bacteria of more than one kind can be propagated in inorganic media. These media, however, of a necessity contained carbon and

* Phil. Trans. Roy. Soc., 1890, B. 107; Nature, xlvi. 1892, 136–138; Annales de l'Institut Pasteur, 1890, 268; Exper. Station Bull. 8 U. S. Dept. of Agriculture, 1892, 42 et seq; Comptes Rendus, 1893, cxvi, 842–849.

† Comparative morphology and biology of the fungi, mycetozoa, and bacteria, by A. de Bary; revised by Isaac B. Balfour. Oxford, 1887, 356.

‡ A handbook of systematic botany, by Dr. E. Warming. Translated by M. C. Potter, London, 1895, 31–32.

§ Nature, May 4, 1893, xlviii, 23; Compt. Rend, 1893, 842, for April 24.

‖ Jour. Chem. Soc., 1886, 651.

¶ Annales de l'Institut Pasteur, 1890, 268.

nitrogen in some available form. Frankland used a solution of ammonium chloride, potassium phosphate, magnesium sulphate, calcium chloride and calcium carbonate.* Here the carbon was supplied by the calcium carbonate and the nitrogen by the ammonium chloride (NH_4Cl). Winogradsky used ammonium carbonate, from which both nitrogen and carbon could be derived.

It is safe to assume, without demonstration, that some such source of supply of these two substances must always be at hand or else these organisms cannot live.

Leaving aside the carbon, the only known mineral sources from which nitrogen could be derived are the nitrates and nitrites and a few others, such as teschemacherite, (acid ammonium carbonate (HNH_4CO_3)), from guano deposits, and sal-ammoniac (ammonium chloride (NH_4Cl)), which occurs about volcanoes.† But while these minerals all occur in nature, sometimes in great quantities, as in the great niter beds of the world,‡ so far as known, they are all produced by organic agencies, and can scarcely be regarded as what geologists know as "rock-forming minerals," that is, minerals that enter into the composition of crystalline, eruptive, metamorphic or widespread sedimentary rocks. It is true that these minerals may be carried into the soil and into the rocks by infiltration, and Mrs. Frankland points out that some forms thrive in carbonated waters.§ But even then bacteria carried in with such waters could not attack the rock-making minerals directly, but only by the formation of organic acids by their own decay. But this simply puts them back in the position of other forms of life which yield organic acids upon decomposing.

Attention is also called to the statement of Storer‖ that Warington, who found "nitric ferment in loam at various depths, was no longer able to detect it with constancy and certainty at depths greater than 36 inches . . . . In none of his experiments was nitrification excited by soils taken from depths of seven and eight feet."

Again he says "In order that nitrates may form in the soil there must be free access of air, as well as a certain amount of humidity and warmth."

* Micro-organisms in their relation to chemical change, by Percy F. Frankland. Nature, xlvi, 1892, 136–138.

† W. L. Watts in his "Across the Vatna Jökul," pp 110, 154, mentions considerable deposits of this mineral about volcanoes. Mr. Watts tells me, however, that he doubts the correctness of the determination.

‡ Stutzer and Burri are said to have found bacteria feeding on saltpeter: Deutsch. Landw. Presse, 1894, xxi, No. 63, p. 610.

§ Bacteria and carbonated water, by G. C. Frankland. Nature, August 20, 1896, 375–376.

‖ Agriculture in some of its relations with chemistry, by F. H. Storer, i, 299 and 305, N. Y., 1892.

Warington also shows* that subsoil nitrification is more active during dry periods because the opening of the soil by cracks admits the air, without which it cannot take place.†

In other words nitrifying bacteria not only do not penetrate the rocks themselves to considerable depths, but they do not even penetrate the soil to a depth of more than three or four feet. In the face of this fact, and of the other fact that our granites are often decomposed to depths of more than 100 feet, it seems quite improbable if not impossible that bacteria are responsible for this deep decay or for any considerable part of it.

Prof. G. P. Merrill in his paper on the principles of rock weathering,‡ summarizes the subject well when he says of bacteria that "the depth below the surface at which such may thrive is presumably but slight, and their period of activity limited to the summer months."

It may be asked whence came the nitrates now in the soil, if not from the rocks of the earth. I do not undertake to answer this question, and only suggest that the nitrogen is contributed to largely by the nitric acid produced by electric discharges in the atmosphere, and by the union of ozone and ammonium in the air.§

It will not be out of place here to refer to other statements regarding the presence of bacteria in the rocks.

Trouessant speaks of Béchamp as holding that the organic substance of the rhizopoda of the chalk has retained its vitality in the rocks, "since a freshly cut piece, taken from the quarry with all possible precautions to exclude air-germs, is able to furnish microbes (bacteria) which multiply rapidly in a favorable medium."‖ This he is said to have demonstrated. I have not seen this statement, which is probably made in Béchamp's large work.¶ I am disposed, however, to believe that there is some mistake about this. It is difficult to believe that plants have preserved their vitality in the rocks for thousands of years. It is not difficult to believe that such forms may have been washed into cracks in the rocks, or that they may have been introduced in some of the many ways in which these organisms elude our watchfulness.

But even if there were no mistake about the matter, the existence of the original bacteria in chalk beds and the decom-

* Jour. Chem. Soc., li, 118.

† U. S. Dept. of Agriculture, Exp. Sta. Bul., No. 8, p. 70.

‡ Jour. Geol., iv, 857.

§ Bericht. deuts. Chem. Gesel., viii, 1481.

‖ Microbes, ferments, and moulds, by E. L. Trouessant, the International Sci. Ser., N. Y., 1892, p. 125, 292.

¶ Les Microzymes dans leurs rapports avec l'hétérogénie, etc.; par A. Béchamp, Paris, 1883.

position of rocks through the agency of bacteria are different questions, except in so far as the supposed bacteria of the chalk may be able to attack the surrounding materials. Trouessant also speaks of Parize finding organisms in plaster and of his belief in their power to disintegrate "schistoid rocks."*

Dr. Bernard Renault recently published a paper on the geologic work of the bacteria† in which he tells of, and reports finding bacteria in several coals.

It should also be remembered in regard to all bacteriological questions that the methods employed in such investigations are not at the command of us all alike. We are compelled to rely upon the statements of specialists, and we need to be more than ordinarily cautious in our discriminations. I am therefore disposed to look with much doubt upon the finding of bacteria in rocks by anyone else than an experienced bacteriologist. Only those who have worked at bacteriology can fully appreciate the difficulties to be encountered and the precautions to be taken in dealing with these organisms in order to prevent being misled by faulty manipulation.

* Op. cit., 123–4.

† Les bactéries et leur œuvre géologique, Revue Générale des Sciences, Oct. 15, 1896; abstr. Nature, Nov. 12, 1896, 40.

Art. XLV.—*On Wellsite, a new Mineral;* by J. H. Pratt and H. W. Foote.

The mineral to be described in this article occurs at the Buck Creek (Cullakanee) corundum mine in Clay Co., North Carolina, and was collected by Professor S. L. Penfield and one of the authors (Pratt) during the summer of 1892 while engaged in work on the North Carolina Geological Survey.

The corundum vein in which the mineral is found is composed chiefly of albite, feldspar and hornblende, and penetrates a peridotite rock, dunite, near its contact with the gneiss. The peridotite outcrop is one of the largest in the State and has been thoroughly prospected for corundum. At only one of the veins opened was the new mineral found, although a careful search was made for it at all the openings, especially those affording feldspar. No mining has been done at the locality since 1891, but if work is resumed and the veins uncovered, more of the material will undoubtedly be found.

The mineral is found in isolated crystals mostly attached to the feldspar but also to hornblende and corundum, and is intimately associated with chabazite which occurs in small transparent rhombohedrons.

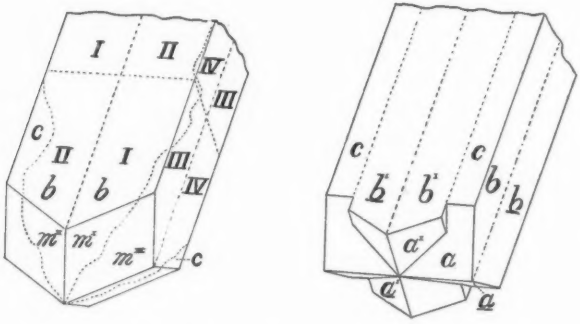
The largest crystals that were observed were not over 1^{mm} in diameter and 2^{mm} in length.

Crystalline form.—The crystals belong to the monoclinic system and they are twinned similarly to those of harmotome and phillipsite. The common habit is shown in fig. 1, which represents a combination of twinning about *c*, 001 and *e*, 011. The crystals are practically square prisms, terminated by pyramidal faces, thus imitating closely a simple combination of a prism of one order and a pyramid of the other in the tetragonal system. The apparent prismatic faces are formed for the most part by the pinacoid faces, *b*, but the crystals interpenetrate each other somewhat irregularly so that portions of the base *c*, 001, coincide with *b*, fig. 1. The lines of twinning on the pinacoid faces between *b* and *b* twinned are generally regular, while those between *b* and *c* and also those which cross the prism faces *m*, 110 (the apparent pyramid) are generally quite irregular. The *b* faces do not show the striations parallel to the edges *b* and *m*, which, meeting along the twinning lines, often reveal the complex nature of such crystals, nor were any reëntrant angles observed parallel to the edges of the apparent prism as are common on phillipsite and harmotome.

Fig. 2 represents another habit of the crystals where *m*, 110

is wanting and a, 100 is in combination with b, 010. The method of twinning is similar to that already described, but the crystals being terminated by a, 100 instead of m, 110 show prominent reëntrant angles at their ends. These crystals are very similar to those of harmotome from Bowling near Dumbarton on the Clyde, described by Lacroix.*

1. 2.



The only forms that were observed were a, 100; b, 010; c, 001 and m, 110, with e, 011 only as twinning plane.

The faces of the crystals are somewhat rounded and vicinal so that the reflections were not very perfect. The angle of the apparent prism $b \wedge b$ twinned is approximately 90°. Also the angle $m \wedge m$ over the twinning plane 011 could be measured only approximately, varying from 0° 49′ to 1° 25′. The approximate angles are given below, and from those marked with an asterisk the following axial ratio was calculated:

$$\breve{a} : \bar{b} : \dot{c} = \cdot 768 : 1 : 1 \cdot 245 ; \ \beta = 53° \ 27' = 001 \wedge 100$$

	Measured.	Calculated.
$b \wedge \underline{b}$, 010 ∧ $\overline{010}$	*90° (over twinning plane)	
$a \wedge \underline{a}$, 100 ∧ $\overline{100}$	*73 6′ (over twinning plane)	
$b \wedge m$, 010 ∧ 110	*58 19	
$c \wedge a$, 001 ∧ 100	53 27 = β	
$c \wedge m$, 001 ∧ 110	60°, 59° 45′, 59° 57′	59° 33′

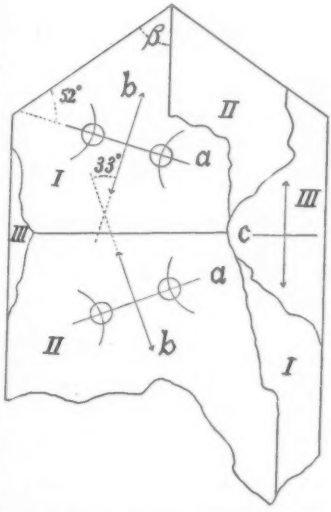
Physical properties.—The crystals are brittle and show no apparent cleavage. The luster is vitreous. Many of the crystals are colorless and transparent while others are white. The hardness is between 4 and 4·5. The specific gravity taken on a number of separate crystals, by means of the heavy solution, varied between 2·278 and 2·366. This variation was probably

* Bull. de la Soc. Min. de France, No. 4, p. 94, 1885.

due to the difference in the ratio of the barium to the calcium in the different crystals.

A section parallel to the pinacoid faces *b*, 010, the apparent prism, revealed in polarized light the structure shown in fig. 3. The parts I and I extinguish simultaneously, as also II and II; while portions III, which are parallel to the basal plane, show parallel extinction. The section showed something of a zonal structure, so that the extinction could only be measured approximately. Using the Bertrand ocular, this was found to be 33° from one pinacoid on to the other over the twinning plane. The axis a makes an angle of 52° with the vertical axis *c* in the obtuse angle β.

3.



The double refraction is positive and weak. The acute bisectrix c is at right angles to the pinacoid 010, and the divergence of the optical axes is large. 2E probably varies from 120° to 130°, but this could not be measured directly.

Chemical analysis. — The mineral was purified for analysis by means of the heavy solution and that which was used varied in specific gravity from 2·278 to 2·360. Water was determined by loss on ignition and silica and alumina by the ordinary methods after fusion with sodium carbonate. The filtrate from the alumina precipitation was evaporated with aqua regia to remove the large excess of ammonium salts and a small amount of ammonium chloride was again added. Calcium, barium and strontium were then precipitated together, with a considerable excess of ammonia and ammonium carbonate, and magnesia was determined in the filtrate. The mixed carbonates were dissolved in hydrochloric acid, evaporated to dryness and taken up in about 300^{cc} of water. The method used for separating barium was that recommended by Fresenius.* To the hot solution, a few drops of acetic acid were added and 10^{cc} of a 10 per cent solution of ammonium chromate containing a small amount of dichromate. After standing until the solution became cold, the clear liquid was decanted

* Zs. Anal. Chem., xxix, 426.

and the precipitate of barium chromate was washed with a weak chromate solution and with water. The precipitate was dissolved in 2^{cc} of pure dilute nitric acid, which was then partly neutralized with ammonia. Ammonium acetate was added and 10^{cc} of chromate solution as before, and after standing, the precipitate was filtered on a Gooch crucible and weighed as $BaCrO_4$.

The filtrate from the barium precipitation was concentrated somewhat, and calcium and the small quantity of strontium precipitated as before. They were ignited and weighed as oxide. Strontium was then separated by treatment with amyl alcohol and determined as sulphate.

The alkalies were determined by a Smith fusion in the ordinary way.

The results of the analyses are as follows:

	I.		II.	Average.	Ratio.		
SiO_2	43·62		44·11	43·86	·731		= 3·00
Al_2O_3	25·04		24·89	24·96	·244		= 1·00
BaO	5·00		5·15	5·07	·033		
SrO	1·12		1·18	1·15	·011		
CaO	5·76		5·84	5·80	·104	·228 =	·93
MgO	0·61		0·62	0·62	·015		
K_2O		3·40		3·40	·036		
Na_2O		1·80		1·80	·029		
H_2O	13·32		13·39	13·35	·742		= 3·04
				100·01			

The ratio of $SiO_2 : Al_2O_3 : RO : H_2O$ is very close to 3 : 1 : 1 : 3, which gives the formula $R''Al_2Si_3O_{10} . 3H_2O$. The ratio of $BaO : CaO : K_2O + Na_2O$ in the above analyses is nearly 1 : 3 : 2 and the theoretical composition calculated for this ratio is given below together with the analysis after substituting for Na_2O its equivalent of K_2O and for MgO and SrO their equivalents respectively of CaO and BaO and then recalculating to 100 per cent.

		Theory for $R''Al_2Si_3O_{10} . 3H_2O$ where R is $\frac{1}{7}$Ba, $\frac{3}{7}$Ca, $\frac{3}{7}$K.
SiO_2	43·12	42·87
Al_2O_3	24·54	24·27
BaO	6·65	6·62
CaO	6·59	7·27
K_2O	5·98	6·10
H_2O	13·12	12·87
	100·00	100·00

Experiments were made to determine at what temperatures the water was driven off, and the results are given in the following table, the mineral being heated in each case until the

weight became constant. The last trace of water could only be driven off by heating the mineral over the blast lamp.

	Loss.	
At 100° C.	nothing.	
125	1·93	4·33
175	1·48	
200	0·92	
260	2·45	3·69
295	1·24	
Red heat	4·96	5·29
Over blast lamp	0·33	
Total	13·31	

As is seen from the above, about one-third of the water, or one molecule, is given off between 100° and 200°, another third approximately between 200° and 300°, while the remainder is expelled only at an intense heat. This would indicate that the water exists in three different conditions in the molecule. If only that which is expelled below 200° be regarded as water of crystallization, the composition would be $H_4R''Al_2Si_3O_{12}+H_2O$.

That the new mineral would be closely related to the phillipsite group of the zeolites, was expected from the first on account of its crystalline form, and this relation is very satisfactorily brought out by a comparison of the crystallographic properties and chemical composition.

They all have very nearly the same axial ratios:

	a	b	c	
Wellsite	·768	1	1·245	$\beta = 53°\ 27'$
Phillipsite	·70949	1	1·2563	$\beta = 55\ \ 37$
Harmotome	·70315	1	1·2310	$\beta = 55\ \ 10$
Stilbite	·76227	1	1·19401	$\beta = 50\ \ 49\frac{3}{4}'$

In their habit and method of twinning, they are also very similar, all the crystals being uniformly penetration twins. This is especially noticeable between the new mineral and phillipsite and harmotome which are common as double twins with c, 001 and e, 011 as twinning planes.

The place of the mineral in the phillipsite group is clearly shown by a comparison of their chemical compositions. Arranged in order of their proportions of silica and water to the bases, we have the following interesting series, in which R represents the bivalent elements:

Wellsite	$RAl_2Si_3O_{10}.3H_2O$
Phillipsite	$RAl_2Si_4O_{12}.4\frac{1}{2}H_2O$
Harmotome	$RAl_2Si_5O_{14}.5H_2O$
Stilbite	$RAl_2Si_6O_{16}.6H_2O$

The ratio of $RO : Al_2O_3$ is constant, 1 : 1, in the series, while

the proportions of silica and water have a constant ratio, 1 : 1, between themselves, except in the case of phillipsite. As there is, however, considerable variation in the analyses of phillipsite, it is not improbable that the ratio of $SiO_2 : H_2O$, given as $4 : 4\frac{1}{2}$, should be in some cases at least, 4 : 4. The minerals then form a gradual series, increasing in the proportions of SiO_2 and H_2O from wellsite to stilbite.

Fresenius* has shown that this group of minerals may be regarded as a series in which the ratio of $RO : Al_2O_3$ is constant, 1 : 1, while the silica and water vary between certain limits. He has assumed as these two limits:

$$RAl_2Si_6O_{16}+6H_2O \text{ and}$$
$$R_2Al_4Si_4O_{16}+6H_2O$$

The first would be a hydrated calcium albite and the last a hydrated anorthite. From a comparison of the wellsite-stilbite series, it seems more probable that the anorthite end would be $RAl_2Si_2O_8+2H_2O$, or doubling this for better comparison with the formula of Fresenius, $R_2Al_4Si_4O_{16}+4H_2O$.

It is not unreasonable to expect that the first or anorthite member of this series may be found in nature and the completed series would then be:

Anorthite limit	$RAl_2Si_2O_8+2H_2O$ (not yet identified)
Wellsite	$RAl_2Si_3O_{10}+3H_2O$
Phillipsite	$RAl_2Si_4O_{12}+4\frac{1}{2}H_2O$ (perhaps $4H_2O$)
Harmotome	$RAl_2Si_5O_{14}+5H_2O$
Stilbite	$RAl_2Si_6O_{16}+6H_2O$

It is also interesting to note that the formula of the new mineral wellsite is the same as that assigned to edingtonite, but the latter is essentially a barium mineral and being tetragonal shows no crystallographic relations to wellsite.

Pyrognostics.—When heated before the blowpipe, the mineral exfoliates slightly and fuses at 2·5–3 to a white bead, coloring the flame slightly yellow. In the closed tube, water is given off at a low temperature. It is very readily decomposed by hot hydrochloric acid with the separation of silica, but without gelatinization. When the water in the mineral is driven off below 265° C., it is nearly all regained on exposing the mineral to the air. If the water, however, is driven off at a red heat, none is regained by the mineral.

Name.—It is with pleasure that the authors name this mineral *wellsite* in honor of their friend Professor H. L. Wells of the Sheffield Scientific School.

In conclusion, the authors wish to express their thanks to Professor S. L. Penfield for his advice and suggestions and the kind interest he has shown during the investigation.

Mineralogical-Petrographical Laboratory,
Sheffield Scientific School, April, 1897.

* Zs. Kr., iii, 42, 1878.

Art. XLVI.—*The Magnetic Increment of Rigidity in Strong Fields;* by Howard D. Day.

In the endeavor to study the magnetic rigidity of filamentary wires in its variation with the thickness of the wire, it seemed desirable to preface the work in question by extending the experiments throughout much stronger magnetic fields than has hitherto been done. The present paper, therefore, treats of the increase of resistance to torque produced by the magnetization of twisted wires of various diameters, when the magnetic field increases to many times the amount needed to bring out the ordinary magnetic saturation.

The object of the research is to make a clear comparison between the phenomenon of magnetization or magnetic intensity on the one hand and the phenomena of magnetic rigidity on the other; to show that the two are quite distinct in character*,—that the former practically subsides in relatively weak fields, whereas the latter are not as fully complete even in the highest fields applied. It thus appears that the manifestation of magnetic saturation is but one phase of a magnetic phenomenon of a far wider range. In other words, if the magnetic qualities of iron be expressed in some way not involving direct or indirect reference to the magnetic moment, then the magnetic relations of the iron to the field will appear in quite a different light; for the influence of the increasing field on the iron will be found to continue with but slowly decreasing magnetic effects up to the limits of observation.

Work on somewhat similar lines has recently been published by Bidwell: but the Joule effect as studied by Bidwell is apparently distorted from its true nature by the occurrence of molecular rotation. The Wiedemann effect investigated in the present paper shows no apparent relation to the magnetic saturation of iron whatsoever, or, at least, is free from any contemporaneous distortion. Hence this effect is peculiarly adapted for expressing the magnetic qualities of iron throughout the wide range under which they continue with but moderately diminished sensitiveness.

The method and apparatus employed in this investigation are adaptations of that used by Barus in his researches† wherein one of two countertwisted wires similar in all respects is magnetized, and the resulting difference in rigidity of the two wires observed. The rigidity of a wire of length l and radius r, twisted by torque τ through an angle θ, is given by

$$\theta n = 2\tau l / \pi r^4$$

* Barus: this Journal, (3) vol. xxxiv, p. 181, 1887.
† Barus: Bull. U. S. Geol. Sur., No. 73, 1891.

Hence, if we look up the same torque, τ, between two counter-twisted wires of the same length, l, and radius r, θn is constant. If, therefore, θn correspond to the unmagnetic and $\theta n''$ to the magnetic wire,

$$\frac{n'-n}{n}=\frac{\theta-\theta'}{\theta'}$$

or, approximately, $\frac{\delta n}{n}=\frac{\delta\theta}{\theta}$. Thus the relative change of rigidity due to magnetization is equal to the relative change of twist due to the same course. This is, in brief, the method pursued in the following work. Apart from the inherent and unavoidable irregularities in the torsional resilience and viscosity of iron, the method unfortunately involves the fourth power of the radius. It has the advantage of a differential method, however, as well as others which appear in the following description.

Pure iron wires were first prepared by drawing through steel plates. These wires, although not as perfect as could be desired for observations by this method, were free from all but microscopic imperfections. They were thoroughly annealed and straightened by being suspended vertically in a glass tube filled with dry hydrogen and then being heated to a cherry red by the passage of an electric current through them. In this way, bright, smooth wires free from corrosion were obtained.

A preliminary trial of the largest size of wires was made in a simple form of the apparatus used. It was then found, that, along with the effect of magnetization on the rigidity of the wire, were involved other effects upon its rigidity due to other causes. The magnetizing coil became much heated and the effect of its rise in temperature upon the rigidity of the enclosed wire was clearly apparent. A group of curves plotted from data obtained by uniting the effects of temperature and magnetization and again by separating the two, the field being kept constant, showed that the increment of rigidity due to the rise in temperature was of the opposite sign to that due to magnetization, namely, negative, and nearly proportional to the increase of temperature. This heat-effect was almost entirely removed by winding the helix about a water-jacket, through which a stream of cold water was kept constantly flowing and within which was the wire to be magnetized. Later, the other wire also was surrounded by a similar water-jacket through which the same stream of water was made to pass. The two wires were thus kept at the same uniform tem-

perature, a necessary precaution owing to the delicacy of the differential method employed. Again, variations in the tensile strain of the wires were found to produce a noticeable effect upon the data obtained. This source of error was removed by giving the lower end of the system of wires vertical freedom of motion, and suspending therefrom a small bucket of mercury, the weight of which was made proportional to the cross-sections of the wires, whenever wires of different diameters were inserted in the apparatus.

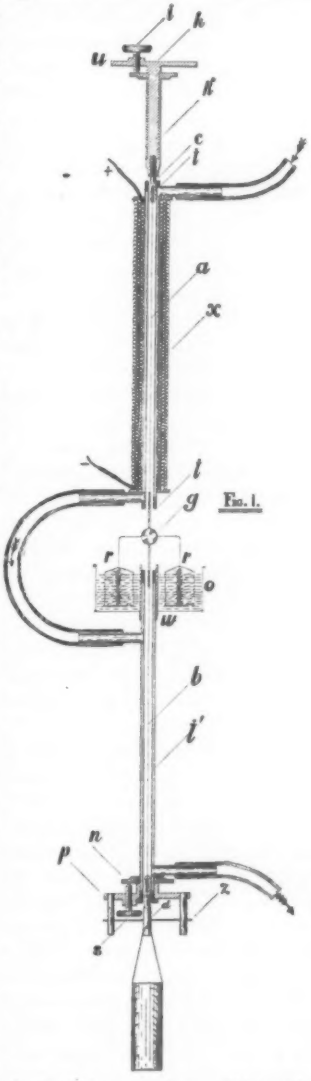


Fig. 1.

The method of observation is made clear by the section drawing of the perfected apparatus given in fig. 1. A vertical system of two iron wires have their adjoining ends soldered between two straight adjacent pieces of brass wire about 4^{cm} long. These brass wires, besides forming a rigid connection between the two iron wires, serve also to support a $\frac{1}{2}''$ circular mirror, *g*, and a pair of vanes, *r*, *r*, of copper foil, which are soldered to the ends of a bent cross-piece of fine brass wire, so as to hang vertically in a circular water-bath, *o*, which, by means of a central piece of tubing slips upon and is supported by the water-jacket *j'*, which envelops the lower wire, *b*. A small spring collar, *w*, holds the bath at the proper position on the water-jacket. These vanes serve to damp the vibrations of the wires.

The upper end of the upper iron wire is soldered to a short piece of brass rod, *c*, which is made to screw tightly into the end of a vertical shaft, *h*, which is free to revolve within the sleeve, *k*. This sleeve is grasped in the jaws of a clamp, which

in turn is fastened to the upright standard supporting the whole apparatus. The shaft *h* is surmounted by a circular plate, *u*, having its outer edge graduated into degrees. This plate is pierced by a thumb-screw, *i*, which, by being screwed down against a flange upon the upper end of the sleeve, *k*, holds the shaft *h* at any position of its revolution within the sleeve. By this means, the system of wires is supported from the standard, and a definite amount of twist may be imparted to the system by revolving the shaft *h*, registered by its graduated head and maintained by clamping the thumb-screw *i*.

In these experiments, iron wires 25^{cm} long in the clear were used. Each wire was surrounded by a water-jacket,—the upper, by the jacket *jj*, the lower, by the jacket *j'*. These water-jackets were made by arranging concentrically two brass tubes differing in diameter by about 3^{mm}. At the ends of the tubes the spaces between them were filled by little collars. An inlet tube was inserted at the upper end of the outer tube and an outlet tube at the lower end. The whole was then made water-tight by soldering. The water-jackets were then connected in series with a source and a sink and a stream of water under pressure passed through, and thus the wire within was immersed in its field and could not have its temperature affected by that of the helix.

It has already been stated that the tensile strain upon the iron wires was regulated by suspending from the lower wire a bucket of mercury varying in weight proportionally with the cross-sections of the wires. A short piece of small brass rod, to which the lower wire was soldered, was slipped within a short sleeve of thin tubing, *d*, and held by a pin piercing both rod and sleeve. The bucket (an old metal cartridge) was suspended from a slanting slit in the lower end of this sleeve.

All increments of rigidity in the magnetized wire were registered as scale-deflections at the eye-piece of an observing telescope focussed upon the mirror *g*. In order to render unnecessary constant shifting of the telescope for focussing upon the mirror, provision was made that one-half of the twist given the wires might be imparted at the upper end in the manner already indicated, and the other half at the lower end. It is evident that the scale-image could thus be kept within the field of the telescope. This was accomplished as follows: A circular plate, *p*, having its outer edge graduated into degrees, was fitted to the lower end of the jacket *j'*, and made free to revolve upon it. This plate could be held in any position of its revolution by a thumb-screw, *S*, which could be screwed up against a flange, *n*, soldered to the water-jacket. Two short pillars, located in a diameter of the plate near its circumference, and each having a longitudinal slit lying along this diam-

eter, extended downward from the plate. These slits were engaged by a cross-wire, z, which passed through the middle of the sleeve d, and was soldered to it. It is readily seen that by this means any definite amount of twist could be imparted to the system of wires at its lower end. Moreover, the cross-wire z being free to move up and down the slits in the pillars, the tensile strain upon the wires would not be altered by the twisting process.

Provision was also made for allowing the wires to take a position of zero twist at the beginning of each experiment; for the entire lower part of the apparatus was supported on the standard already referred to by means of a clamp, which could be raised or lowered by turning a thumb-screw. To accomplish this, the lower half of the apparatus was raised by means of the screw, until the cross-wire z swung free of the slits in the pillars. The system of wires was then free to assume its position of zero twist. When they had assumed this position, the plate p was turned until the slits in the pillars were directly above the cross-wire z, when it was clamped and the apparatus lowered into its former position, the slits again engaging the cross-wire. The total twist imparted to the system would then be registered as the sum of subsequent revolutions of the plates p and u.

The helix was supported in position on the standard by wooden clamps. The standard itself was a vertical frame-work of brass piping embedded in a solid cast-iron base mounted on bevelling screws, the whole apparatus being located on a pier. By suspending the rubber hose connections from the standard in loops, the apparatus was rendered free from sensible jarring due to the passage of a stream of water under pressure through the water-jackets.

For regulating the strength of the current producing the field within the helix, a liquid rheostat was used. It was found, that, by the use of a rheostat where resistance coils were successively thrown into or out of the circuit, the magnetization of the wire was hindered as if by mechanical jarring. Moreover, by the use of a liquid rheostat, much finer gradations of the current could be made,—an important requisite in the carrying out of the experiments.

In this way, with a maximum E. M. F. of 165 volts, the current strength was made to vary between 0 and 15 amperes. The corresponding field-strength is obtained by substituting the constants given below for the helix in the annexed formula.

Constants of helix.

Length, 249^{m}.
Gauge of wire, 80 turns=7·5^{cm}.
Outside circumferences of layers of helix:—

1st	layer	·0470^{m}
2d	"	·0518
3d	"	·0569
4th	"	·0620
5th	"	·0667
6th	"	·0722
7th	"	·6767
8th	"	·0827

Formula for strength of field.

Mean field (in dynes) along the axis within the helix:—

$$X=\frac{\pi n I}{ab}\left\{\sqrt{(a+b)^2+r^2}-\sqrt{(a-b^2+r^2}\right\}$$

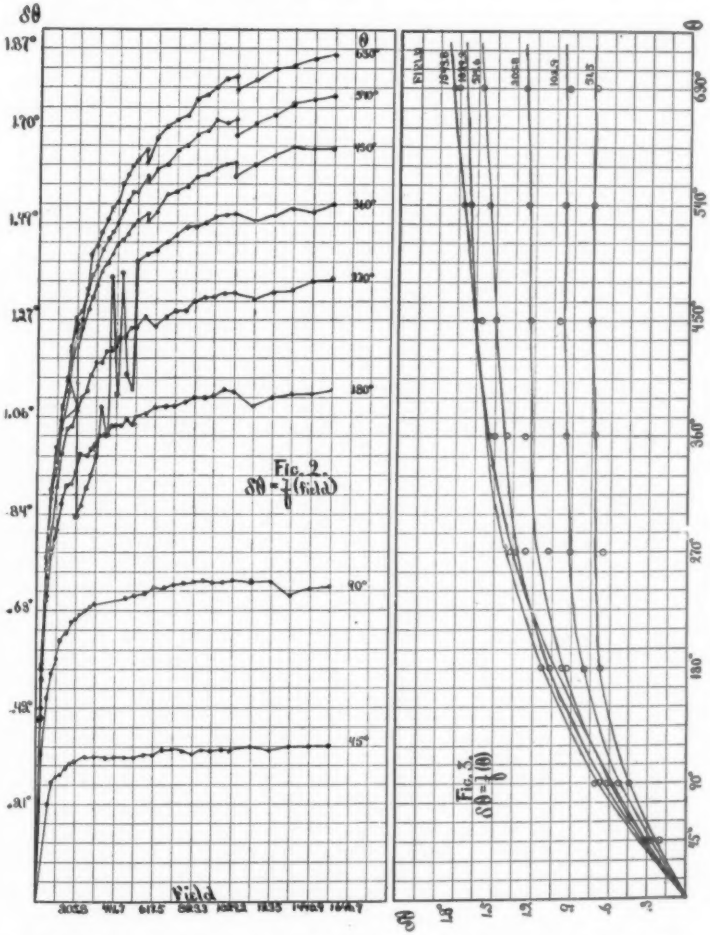
where b=distance of any point on axis of coil from center of coil.
r=radius of coil.
$2a$=length of coil.
n=total number of turns in coil.
I=intensity of current in C. G. S. units.

From these constants, it is seen that the iron wire within the helix was exposed throughout its length to the magnetizing influence of fields whose mean strength along the axis of the helix reached the maximum value of 1,600 C. G. S. units.

During the course of the experiments, fresh sets of wires varying in diameter from ·48^{mm} to ·18^{mm} were frequently inserted in the apparatus, and the examination of the increment of rigidity was carried out in full for each set. Different amounts of twist were locked up in the countertwisted wires and at definite stages in the twisting process the upper wire was exposed to the magnetic field of the surrounding helix, which was varied in strength by successive increments of 25, 50, or 100 units from zero to the maximum value given above. For each definite value of the field-strength, the initial twist, θ, was noted and the corresponding increment of rigidity registered as a scale-deflection.

Marked effects of viscosity were in evidence throughout the experiments, and hysteresis was frequently observed. The method furnished an excellent means for observing the latter. The effects of viscosity were, however, irregular in all ways. They were most pronounced as the elastic limit of the wires was approached,—roughly, when θ equalled 4π. Viscous slip was indicated, sometimes by progressive, sometimes by jerky, scale-deflections, according as the cohesion of a few molecules

or of whole groups of them gave way at once. Upon the charts is given the number of degrees of twist, θ, registered by the index heads u and p. These can be but approximate values of the twist actually existing in the wires, for, the system being differential, only the excess of slip in one wire over



that in the other could be detected. The sign of the scale-deflections due to viscous slip was apparently accidental, yet it is to be noted that most of the slip took place in the lower—the unmagnetized—wire; this would be a natural result of an increase of the rigidity of the upper wire by magnetization.

The data obtained, when charted, show very clearly the result aimed at in the investigation. The accompanying set of charts, obtained from the examination of a set of wires whose diameter was ·294^{mm}, which is typical of the entire series, is sufficient to exhibit the results obtained. Here, $\delta\theta$, the increment of twist θ, is, as already pointed out, a very approximate relative value for the increment of rigidity, if θ be taken as the value of the initial twist. The values of $\delta\theta$ and θ are to be applied to the entire length of both wires, namely, 50^{cm}; for it is readily seen that $\delta\theta$ represents twice the actual change in the twist of either wire. Since, however, no attempt is made in this paper to give an absolute value for the increment of rigidity, the charts exhibit the true relations existing between θ, $\delta\theta$, and the field-strength.

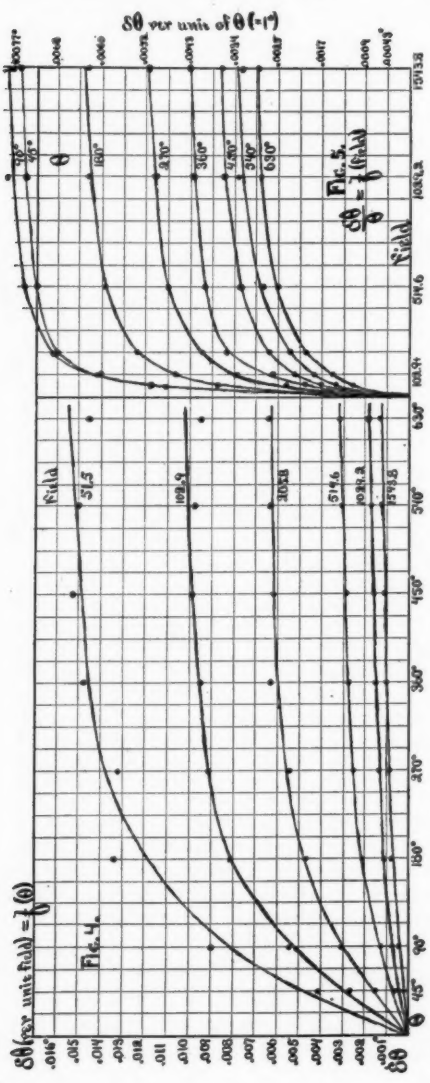


Fig. 2 shows a family of curves in which $\delta\theta$ is a function of the field-strength. In each of these curves $\delta\theta$ is an increasing function of the field, and it is seen, that even for the largest fields used, the increment of rigidity shows no near approach to a limit; moreover,

as, in the series of curves, the initial twist, θ, becomes greater, the slope of the curves at the limit of observation also becomes greater,—showing that, with any given field, the possibility of reaching any limiting value for the increment of rigidity becomes more and more remote with the increase of θ.

The relation between the rate of change of $\delta\theta$ and the field-strength is made clearer by reference to fig. 3. These curves, plotted from the same data as those of fig. 2, show $\delta\theta$ to be an increasing function of θ. Again, as the field is increased, at the upper limit of twist the slope of the curves increases; that is, while the possibility of reaching a limiting value for $\delta\theta$ by increasing θ is remote, a concurrent increase of the field-strength renders it still more remote.

Other relations not so evident are pointed out by figs. 4 and 5, which give: fig. 4, $\delta\theta$ per unit of field as a function of θ; fig. 5, $\delta\theta$ per unit of θ as a function of the field. They show that, while the increment of rigidity increases with the total strength of field and at the same time with the total initial torque, yet, per unit of field and per unit of initial twist, the rate of increase of the increment of rigidity diminishes and approaches the limit zero.

In proportion, then, as the field becomes stronger, the increment of rigidity varies more and more regularly with the twist, the tendency being that, in fields indefinitely large the increment of rigidity would be proportional to the twist applied.

In conclusion, in preparing this paper, acknowledgment is to be made to Dr. Barus of the University for assistance in interpreting the principles involved in the results.

Wilson Laboratory, Brown University.

Art. XLVII.—*A Geologic Fault at Jamesville, near Syracuse, N. Y.;* by Philip F. Schneider.

[Read before the Onondaga Academy of Science, April 30, 1897.]

In Vanuxem's final report on the geology of the Third District of New York, page 149, we read: "Near Manlius square, two excavations were made for coal, one on the farm of Mr. Nettleton, near the turnpike, about a mile west of the village." "At this place there is a fault, the first seen upon the upper range going west."

Heretofore, local geologists have always maintained that the preceding quotation referred to a large fracture filled with calcite, which exists in the Helderberg series about a mile west of the village of Manlius, and not to a fault in the true sense of the word. While at first the question does not appear to warrant any lengthy investigation, still the fact that it is in the very midst of the horizontally stratified Paleozoic rocks of Central New York, which have recently furnished numerous evidences of igneous dikes; as at Syracuse, N. Y., at DeWitt, at Manheim, and at Ithaca; and since the location of the fault as reported by Vanuxem is right in the midst of the noted Green Lake region, which lakes have frequently been regarded as the craters of extinct volcanoes; and lastly since faults are practically unknown in this part of the state, the matter is of more than ordinary interest. This being the case, I determined to look into the matter and several visits to that locality during the past summer disclosed the following facts.

On traveling to the eastward over the turnpike from Jamesville to Manlius (Jamesville being the first station on the D. L. and W. Railroad and about seven miles south of Syracuse) the road rises almost immediately from the level plain in which the former village stands, to the top of the Helderberg escarpment, a rise of some 200 feet. After reaching the top of this escarpment the road is practically the top of the upper layer of the Corniferous limestone and for a distance of several rods is destitute of soil or earth. Half-a-mile east of Jamesville the road rises over the Marcellus shale and Goniatite limestone and for the next mile passes over this formation. Then the road drops into a small valley slightly more than a half mile in width and here is where we find the first trace of the fault. On reaching the valley at the foot of the hill, one finds a small stream crossing the turnpike and but a short distance to the west of its intersection with the direct road from Fayetteville to Pompey. At this point the stream courses over layers of the Corniferous limestone. Turning to the

right and leaving the turnpike one travels up stream to the southward. This on the farm of Mr. F. B. Fillmore. At a distance of 204 feet from the road we find ourselves at the axis of a small anticline, so slight in fact that it would be disregarded even in this region of regularly stratified rocks were it not for the fault just beyond. At a distance of 345 feet up stream we have come to an actual fault, although the layers from the direction of the turnpike are still dipping at the same slight angle to the southward.

The layers, however, which dip toward this point from the southward are those which immediately rivet our attention, in fact they could scarcely fail to attract the most casual observer. We are still in the bed of the stream, the only place where the layers are sufficiently exposed for examination. From the fault-line which is transverse to the direction of the stream, the layers rise in a sharp monocline, the cause producing the fault having bent the layers of hard Corniferous limestone so that they stand vertical at the fault-line and form as it were the arc of a great ellipse. The layers dip at a very great angle at first, then at a continually smaller and smaller angle until at a distance of 396 feet up stream from the fault we again have perfectly normal conditions. The several layers of limestone forming the west bank of the stream very distinctly show the conditions described. That there must be an actual break together with a displacement is obvious, for we have the flexed layers dipping to the north, slightly at first, then sharply, then standing vertical, met by layers of the same rock which are practically horizontal. The actual displacement appears to be about fifteen feet although this could not be accurately determined. Following up stream still farther we find no further evidences of the disturbance but simply the regular layers of Marcellus shale presently containing the seams of Goniatite limestone.

Although the rocks in the neighborhood of the fault are so deeply covered with drift and soil as to be wholly concealed, the topography indicates that the fault-line extends to the eastward for some distance. Further traces may be seen in the gutters on the sides of the road from Fayetteville to Pompey Hill, which is but a few rods to the east of the locality just described. These traces in the road are scarcely noticeable and no additional facts were learned from them.

By following the turnpike to the eastern side of the valley, however, we find another small stream crossing the road at a distance of 2600 feet from the first mentioned locality. This is near the house of Mr. Gifford and the stream leads back into Gifford's Glen. By turning to the right and following up stream we continually rise over the edges of layers of Cor-

niferous limestone, until at a distance of 260 yards from the turnpike we come to a comparatively level spot which is filled with the detritus of the stream, probably indicating that the top of the limestone has been reached. But from the southern end of this level stretch rises a great curved wall, as it were, of limestone. This can be noticed merely for the width of the stream. It looks just as though one layer had been stretched across the channel of the stream and then by the application of great pressure at the northern end it had been forcibly bent down some twenty or more feet there. The distance up over the inclined layers and back to the horizontal rocks again is 232 feet. The sharpest part of the bend is toward the northern end where the layers stand almost vertically. This folded layer (for only the one is visible) has been fractured in various places, showing crevasses several inches in width and extending downward a foot or more. The banks of this stream are composed either of the fissile shales of the Marcellus group, or of the dark colored soil which is the decomposed shale, as the many small pieces which it contains readily prove. Thus the layers of limestone are on a level with the shales, and a part of the limestone some 20–25 feet above the lowest part of the shales.

Beyond the southern end of the monocline we find merely the horizontal layers of shale and presently the contained layers of the Goniatite limestone with its characteristic fossils, but there are no further traces of the disturbance up stream. That the disturbance here in Gifford's Glen is identical with that mentioned by Vanuxem as existing on the Nettleton farm can hardly be doubted. The conditions are very similar, and the shales have an unusually dark color which, together with their bituminous odor, would readily suggest the existence of coal. The fault-line connecting these two most prominent disturbances would soon lead us to the eastward from Gifford's into the hillside composed of thick Marcellus shales, and as there are no streams in this direction which have worn through the shales to the underlying limestone, the fault could not be traced beyond this point. As the greatest amount of displacement observed exists at Gifford's Glen, it would seem that the fault exists for a considerable distance to the eastward from that point. That it must extend for some distance to the west of Fillmore's is also evident. The fault-line connecting these two disturbances lies 20° north of east; the localities are nearly a half mile apart.

Further observations along this parallel may result in bringing other traces of the fault to light, but this is not probable. Special interest and importance attaches to this subject at this time, because it gives to us another disturbance in this region where until recently such disturbances were not supposed to exist.

Syracuse, N. Y.

Art. XLVIII.—*On Certain Double Halogen Salts of Cæsium and Rubidium;* by H. L. Wells and H. W. Foote.

1. The Complicated Rubidium-Antimony Chloride.

Remsen and Saunders* have described a salt to which they gave the formula $23RbCl.10SbCl_3$ as the most probable one. Wheeler,† working in this laboratory, confirmed Remsen and Saunders' results and discovered besides an analogous bromide, to which the probable formula $23RbBr.10SbBr_3$ was given. Remsen and Brigham‡ prepared the salt $23RbCl.10BiCl_3$. Herty§ has since described the two potassium salts $23KCl.10SbCl_3$ and $23KBr.10SbBr_3.27H_2O$, and some mixtures of these two salts.

In view of all this work, there can scarcely be a doubt as to the existence of a type of salts with a somewhat complicated ratio, but in view of the fact that this complicated ratio 23 : 10 is apparently an exception to the simplicity of composition of all other carefully investigated double halogen salts, the subject seemed worthy of some further investigation. For the purpose, we have studied only the rubidium-antimony chloride of Remsen and Saunders, as this salt is readily prepared and is capable of repeated recrystallization from hydrochloric acid solution.

The possibility suggested itself that the product might consist of two simpler salts of similar or identical crystalline form, which were capable of crystallizing together, and that previous investigators had made use of conditions which resulted in obtaining a constant mixture of two such salts. Although this supposition had scarcely any probability in view of the existence also of the rubidium-antimony bromide and of the two potassium salts, we have put the question to test by repeatedly recrystallizing the salt, using not only ordinary dilute hydrochloric acid for this purpose, but also more dilute and much more concentrated acid and also an alcoholic hydrochloric acid solution. As will be seen from the analyses, given beyond, no variation in composition could be detected by the use of these widely varying solvents for recrystallization, and it therefore appears impossible that the salt can be a mixture.

As a starting point, we used a solution in hydrochloric acid containing the constituents RbCl and $SbCl_3$ in the exact molecular proportion 23 : 10. Product A was the first, B the third and C the fifth recrystallization from pure dilute hydrochloric acid. The product D was obtained by adding concentrated

* Am. Chem. Jour., xiv, 155.
† This Journal, xlvi, 269.
‡ Am. Chem. Jour., xiv, 174.
§ Am. Chem. Jour., xvi, 490.

hydrochloric acid to a nearly saturated warm solution of the salt in dilute hydrochloric acid. E was obtained from a very strong hydrochloric acid solution formed by passing a rapid current of hydrogen chloride gas into the solution as it cooled. F was obtained by recrystallizing the salt from hydrochloric acid which was kept as dilute as it could be without producing the basic double salt to be described beyond. G was a product obtained by recrystallizing the salt from a mixture of equal volumes of dilute hydrochloric acid and alcohol.

The two products obtained from concentrated hydrochloric acid solution had a pale yellow color while the others were all white. The crystals were usually well-formed six-sided plates which showed no definite optical properties.

The analyses of the various products are as follows:

	Rubidium.	Antimony.	Chlorine.
A	39·23	23·85	37·01
B	39·23	23·84	36·99
C	....	23·91	....
D	39·25	23·98	....
E	39·31	23·89	....
F	39·03	23·86	....
G	39·11	23·90	....
Average	39·19	23·89	37·00

Method of analysis.—For the determination of antimony and rubidium, a portion of about one-half a gram was dissolved in water and enough hydrochloric acid to prevent antimony oxychloride from precipitating. The solution was heated to boiling and hydrogen sulphide passed in. The solution was then cooled and the antimony sulphide filtered on a Gooch crucible and washed with water and with alcohol. The crucible was then slowly heated to 230° and cooled in an oven filled with carbonic acid. The precipitate was weighed as Sb_2S_3. The filtrate containing rubidium was evaporated with sulphuric acid and the residue ignited in a stream of air containing ammonia and weighed as Rb_2SO_4. Chlorine was determined by dissolving a separate portion in water acidified with tartaric and nitric acids and precipitating with silver nitrate. This was allowed to stand for some time and the precipitate was then collected on a Gooch crucible and weighed. The methods used are almost identical with those of Wheeler.

The accuracy of the antimony determination was checked in the following manner. The salt $Cs_3Sb_2Cl_9$ was prepared from very pure materials and carefully recrystallized and antimony determined by the above method. The per cent of antimony is nearly the same as in the rubidium antimony salt under consideration. The following results were obtained:

	I.	II.	III.	IV.
Per cent Sb found	25·37	25·42	25·43	25·44
" " calculated	25·13	....	....	....

The atomic weights used in all the calculations were Rb 85·43; Sb 120·43; Cl 35·45; S 32·07; Ag 107·92; Cs 132·89.

Since the method used for the determination of antimony gives results which are slightly too high, we believe that a deduction of the average error 0·25 per cent from the antimony found in the analyses of the rubidium salt will give a result which is nearer the truth.

	Rb.	Sb.	Cl.
Average previously given	39·19	23·89	37·00
Average with correction for Sb	39·19	23·64	37·00
Calculated for $Rb_{23}Sb_{10}Cl_{53}$	38·92	23·86	37·22
Calculated for $Rb_7Sb_3Cl_{16}$	39·18	23·66	37·16

It may be noticed that the results agree rather more satisfactorily with the formula $7RbCl . 3SbCl_3$ than with the more complicated one advanced by Remsen and Saunders. The differences between these formulæ are, however, so slight that it is probably entirely impossible to decide between them by means of chemical analysis, the ratio Rb : Sb being 230 : 100 in one case, and in the other 233 : 100. However, since it is customary to use the simplest applicable formula for a chemical compound, we propose the formula $7RbCl . 3SbCl_3$ for this salt and corresponding formulæ for other salts of this series. Herty's hydrous salt, to which he gave the formula $23KBr . 10SbBr_3 . 27H_2O$, agrees well with the formula $7KBr . 3SbBr_3 . 8H_2O$. It must be admitted that the 7 : 3 ratio is an unusually complicated one, but it is far simpler than 23 : 10 and is scarcely a marked exception to the general simplicity of double halogen salts.

2. A rubidium-antimony oxychloride, $2RbCl . SbCl_3 . SbOCl$.

In attempting to recrystallize the salt $7RbCl . 3SbCl_3$ from very dilute hydrochloric acid, just enough to prevent the formation of antimony oxychloride, this new salt was obtained in the form of short colorless prisms possessing a rather high luster. It can be recrystallized from very dilute hydrochloric acid.

The following results were obtained from analyses of separate crops:

	I.	II.	Calculated for $2RbCl . SbCl_3 . SbOCl$.
Rb	26·54	26·68	26·68
Sb	37·58	37·36	37·61
Cl	32·75	32·80	33·21
O (by diff.)	3·13	3·16	2·50

It is interesting to notice that Benedict* has described the potassium salt $2KCl . SbCl_3 . SbOCl$, which corresponds exactly to this rubidium compound.

3. The Cæsium-Bismuth Chlorides and Iodides

The double chlorides of bismuth with cæsium have been described by Remsen and Brigham.† These authors did not state, however, how widely the conditions had been varied, and we have repeated the work, varying the proportions of cæsium and bismuth as much as possible, and have found exactly the same salts as described by them. These salts are,

$$3CsCl . BiCl_3$$
$$3CsCl . 2BiCl_3$$

$3CsCl . BiCl_3$.—This salt forms in colorless plates when 50^g of cæsium chloride are mixed in hydrochloric acid solution with from $1-25^g$ of bismuth chloride. The analyses were made on samples, dried but a short time in the air, which apparently contained a little mechanically included water. The following results were obtained:

	I.	II.	Calculated for $3CsCl . BiCl_3$.
Bi	24·80	24·47	25·36
Cs	47·94	----	48·66
Cl	----	----	25·98

$3CsCl . 2BiCl_3$.—When 50^g of bismuth chloride are mixed with from $1-80^g$ of cæsium chloride, the salt $3CsCl . 2BiCl_3$ crystallizes in light yellow needles, sometimes broadened and looking like plates and again much shorter and thicker.

The following analyses were made:

	I.	II.	Calculated for $3CsCl . 2BiCl_3$.
Bi	36·99	36·58	36·67
Cs	34·69	34·94	35·17
Cl	----	----	28·16

$3CsI . 2BiI_3$. Cæsium-Bismuth Iodide.

We could obtain only one double iodide of bismuth and cæsium, although the proportions of cæsium and bismuth were varied greatly. The salt formed as a crystalline precipitate, difficultly soluble especially in an excess of cæsium iodide, when 1^g of bismuth iodide was added to 50^g of cæsium iodide and when 1^g of cæsium iodide was added to 50^g of bismuth iodide. With an excess of cæsium, the color was a bright red,

* Proc. Am. Acad., xxix, 212. † Amer. Chem. Jour., xiv, 179.

while with an excess of bismuth the color was more of a reddish brown.

Methods of Analysis.—The methods here given were used in both the double chlorides and iodide of bismuth.

Halogens were determined as the silver salts being precipitated from a solution acidified with tartaric and nitric acids and, after standing, filtered and weighed on a Gooch crucible. As Remsen and Brigham had mentioned a difficulty in determining bismuth, we made a few determinations of it in Bi_2O_3, which was made by precipitating $BiONO_3$ with water from a nitric acid solution of $Bi(NO_3)_3$, and heating the precipitate to constant weight in a platinum dish. The method finally adopted was to dissolve the substance in water slightly acidified with hydrochloric acid and precipitate Bi_2S_3 from the cold solution with hydrogen sulphide. The precipitate was filtered and immediately dissolved in nitric acid and digested for some time on the water bath until completely decomposed. The sulphur was filtered off and the filtrate, diluted to about 300–400^{cc}, was heated and ammonium carbonate added in slight excess. It was placed on the water bath for an hour or two, until the liquid had become nearly clear and the excess of ammonium carbonate had been driven off, and it was then filtered on a Gooch crucible and ignited strongly over a Bunsen burner and weighed as Bi_2O_3.

Two determinations on Bi_2O_3 gave the following results:

I	Amt. Bi_2O_3 taken	$= 0{\cdot}1979^g$	Amt. Bi_2O_3 found	$= 0{\cdot}1974^g$
II	" " "	$= 0{\cdot}3604$	" " "	$= 0{\cdot}3617$

The filtrate from the bismuth precipitation was evaporated with sulphuric acid and ignited in a stream of air containing ammonia. The residue was weighed as Cs_2SO_4.

The results obtained from the analysis of the double iodide were as follows:

	I.	II.	Calculated for $Cs_3Bi_2I_9$.
Bi	21·34	21·15	21·25
Cs	20·75	20·31	20·38
I	----	58·02	58·37

Sheffield Chemical Laboratory, New Haven, January, 1897.

ART. XLIX.—*On the Double Fluorides of Zirconium with Lithium, Sodium and Thallium;* by H. L. WELLS and H. W. FOOTE.

IN a previous article* we have described the cæsium-zirconium fluorides, and upon comparing these with the corresponding ammonium and potassium salts, which had been previously described by Marignac† it was observed that the types of salts formed varied with the molecular weights of the alkaline fluorides in an interesting manner. The fluorides of smaller molecular weight gave types with a larger relative number of these molecules, while the fluorides of higher molecular weights combined with more zirconium fluoride than the others. This relation is made clear from the following table, which was given in the previous article referred to:

3 : 1 Type.	2 : 1 Type.	1 : 1 Type.	2 : 3 Type.
$3NH_4F.ZrF_4$	$2NH_4F.ZrF_4$	----------	----------
$3KF.ZrF_4$	$2KF.ZrF_4$	$KF.ZrF_4$	----------
----------	$2CsF.ZrF_4$	$CsF.ZrF_4$	$2CsF.3ZrF_4.2H_2O$

The present investigation was undertaken with the view, in the first place, of testing the apparent rule with lithium fluoride, which has a lower molecular weight than the fluorides previously experimented upon. Our expectations were realized by the preparation of the salt $4LiF.ZrF_4.\frac{2}{3}H_2O$. The salt $2LiF.ZrF_4$ was also obtained, but, in spite of a careful search, no intermediate 3:1 salt could be discovered. The following table, giving the lithium, potassium and cæsium salts, shows a perfectly symmetrical gradation in types according to the atomic weights of the alkali metals, except that the intermediate lithium salt is missing.

Type.	Lithium salts.	Potassium salts. (Marignac.)	Cæsium salts.
4 : 1	$4LiF.ZrF_4.\frac{2}{3}H_2O$	----------	----------
3 : 1	----------	$3KF.ZrF_4$	----------
2 : 1	$2LiF.ZrF_4$	$2KF.ZrF_4$	$2CsF.ZrF_4$
1 : 1	----------	$KF.ZrF_4.H_2O$	$CsF.ZrF_4.H_2O$
2 : 3	----------	----------	$2CsF.3ZrF_4.2H_2O$

Marignac's two ammonium salts, 3:1 and 2:1, also enter the series symmetrically.

We have investigated also the thallous-zirconium fluorides, since the high atomic weight of thallium led us to expect that it would possibly yield a series of salts symmetrical with those

* This Journal, IV, i, 18. † Ann. Chim. Phys., ix, 257.

of the alkali metals with a still higher ratio of zirconium than was the case with cæsium. Such was not the case, however. The salts discovered were:

$3TlF.ZrF_4$, $5TlF.3ZrF_4.H_2O$, $TlF.ZrF_4$ and $TlF.ZrF_4.H_2O$.

Two of these three types of thallous salts correspond to types of alkali-metal salts, while one type, the 5 : 3, is a new one, but the series is not symmetrical with the others according to the atomic weights.

Since Marignac had described but one sodium-zirconium fluoride, $5NaF.2ZrF_4$, and since this differs from all other alkaline zirconium fluorides, we have undertaken a new investigation of the sodium salts. As a result, we have fully confirmed Marignac's results as to the 5 : 2 salt, which is the one most readily obtained, and we have succeeded in preparing a new salt, $2NaF.ZrF_4$, which corresponds to the most usual type of double halogen salts of tetravalent elements. It is evident, however, that the sodium salts, like those of thallium, do not form a symmetrical series with the others.

The following table gives a list of the sodium and thallium salts and shows the positions, "X" of the other compounds prepared by Marignac and ourselves.

Type.	Lithium salts.	Ammonium salts. (Marignac)	Sodium salts.	Potassium salts. (Marignac.)	Cæsium salts.	Thallium salts.
4 : 1	X	--	--------	--	--	--------
3 : 1	--	X	--------	X	--	$3TlF.ZrF_4$
5 : 2	--	--	$5NaF.2ZrF_4$	--	--	--------
2 : 1	X	X	$2NaF.ZrF_4$	X	X	--------
5 : 3	--	--	--------	--	--	$5TlF.3ZrF_4.H_2O$
1 : 1	--	--	--------	X	X	$TlF.ZrF_4$ and $TlF.ZrF_4.H_2O$
2 : 3	--	--	--------	--	X	--------

While our investigation has shown that the rule for the variation of the types with the atomic weights applies only partially to the zirconium double fluorides, we have shown at least that the variety of types is remarkable and it is also noticeable that the ratios are nearly the simplest that can exist in such number between the extreme limits 4 : 1 and 2 : 3.

Preparation.—Thallium fluoride was prepared by dissolving the metal in sulphuric acid, adding an excess of baryta water, filtering and passing carbonic acid into the hot solution. The filtrate from this precipitation was evaporated and treated with hydrofluoric acid in excess. The salts were prepared by mixing the acid solutions of the fluorides in varying proportions, evaporating and cooling to crystallization. The salts were

then removed and pressed between filter papers till dry. In all cases, they were stable in the air.

Method of analysis.—Zirconium and the alkalies were determined by evaporating the salt with sulphuric acid to drive off hydrofluoric acid, precipitating zirconium hydroxide with ammonia and weighing ZrO_2. The filtrate was evaporated to dryness and the alkali determined as sulphate, either by igniting with ammonium carbonate or heating in a current of air containing ammonia. When thallium was present, the fluoride was dissolved in water, a little sulphurous acid added to make sure that the thallium was all in the univalent condition, and the zirconium precipitated with ammonia. The precipitate needed to be very thoroughly washed. The filtrate was evaporated nearly or quite to dryness to remove free ammonia, diluted to a volume of about 100^{cc}, heated to boiling and potassium iodide added in excess to precipitate thallium iodide. This was collected on a Gooch crucible, washed with eighty per cent alcohol, dried at 100° C. and weighed. Fluorine was determined by the ordinary calcium fluoride method after precipitating zirconium with ammonia and removing ammonium salts by evaporation with sodium carbonate. Water was determined by heating the salt in a combustion tube behind a layer of dry sodium carbonate and collecting the water in a calcium chloride tube.

Salts of Lithium.

$2LiF.ZrF_4$.—This salt forms when from 0·7^g to 2^g of lithium fluoride are added to 20^g of zirconium fluoride. The crystals are hexagonal, showing prism and pyramid and rarely a basal plane. In appearance, they are very much like crystals of quartz from Herkimer Co., N. Y., but they are very small. On recrystallizing, the 4 : 1 salt was formed.

Separate crops were analyzed with the following results:

	I.	II.	Calculated for Li_2ZrF_6.
Li	6·03	6·39	6·42
Zr	41·81	41·64	41·28
F	....	51·62	52·30

$4LiF.ZrF_4.\frac{2}{3}H_2O$.—This was the most unsatisfactory salt obtained, though it seems undoubtedly to establish the 4 : 1 type. As lithium fluoride is very insoluble, only a comparatively small amount could be dissolved in zirconium fluoride and apparently we could not go far enough toward the lithium end to get the salt in pure condition. It formed in a crust ordinarily and the crystals were very small. Under the microscope, no mixture with another salt could be found in the

crops analyzed. Once, however, it was obtained mixed with the 2 : 1 salt, as seen under the microscope, showing there could probably be no intermediate salt. Various conditions were tried and crops were obtained from both hot and cold solutions. It forms when 5 to 7^g of lithium fluoride are mixed with 20^g of zirconium fluoride. On recrystallizing, lithium fluoride is precipitated.

Following are the results of the analyses:

	Li.	Zr.	H_2O.	F.
I	9·54	33·14	4·83	....
II	....	....	4·93	....
III	9·79	33·30	4·35	53·16
IV	....	33·23	....	....
V	....	33·02	....	....
Calculated for $Li_4ZrF_8 . \frac{2}{3}H_2O$	9·93	31·91	4·26	53·90

Salts of Sodium.

$2NaF . ZrF_4$.—This salt crystallizes in very minute crystals of hexagonal outline, coming down in a crust when from one to two parts of sodium fluoride are added to fourteen parts of zirconium fluoride. The salt does not recrystallize. The following results were obtained from separate crops. The water was probably mechanically included.

	I.	II.	Calculated for Na_2ZrF_6.
Na	18·66	18·41	18·40
Zr	34·78	36·21	36·00
H_2O	1·96	0·50	....
F*	44·60	44·88	45·60

$5NaF . 2ZrF_4$.—Marignac has previously described this salt, which comes down under wide conditions in very good crystals and recrystallizes easily. Prof. L. V. Pirsson has kindly examined the crystals and made the following report:

"The crystals show good sharp forms but are very small. They appear distinctly orthorhombic in habit, consisting in the main of rather stout prisms, made up of two prismatic planes, *m* and *m'* and terminated by a rather steep brachydome. In another habit, which is rarer, the front pinacoid, *a*, is broadly developed while the prisms are very small; this type also shows at times a pyramid, *p*. The plane of the optic axes lies in the base and $a = c$, $b = a$, $c = b$. The optic angle is large and it could not be told whether *a* or *b* was the acute bisectrix. The double refraction is very low. The crystals in their form strongly recall the figures of chrysolite (olivine) shown in the mineralogies."

* By difference.

The analyses gave the following results from different crops:

	I.	II.	Calculated for $Na_5Zr_2F_{13}$.
Na	21·15	21·09	21·23
Zr	33·63	33·55	33·22
F*	45·22	45·36	45·57

Salts of Thallium.

$TlF.ZrF_4.H_2O$ and $TlF.ZrF_4$.—These salts crystallize in somewhat concentrated solutions when one part of thallium fluoride is mixed with three or four parts of zirconium fluoride. The analyses invariably show an excess of zirconium fluoride. The hydrous salt crystallizes in needles, if the solution be cooled before precipitation occurs. If the solution is evaporated until crystals begin to form and then cooled, the anhydrous salt deposits in minute square plates. The salt gives the 5:3 type on recrystallizing. The following results were obtained:

	I.	II.	Calculated for $TlZrF_5.H_2O$.
Tl	48·43	47·91	50·05
Zr	22·93	23·16	22·15
F	----	23·17	23·37
H_2O	3·89	4·80	4·43
			Calculated for $TlZrF_5$.
Tl	50·16	49·91	52·37
Zr	23·86	24·08	23·17
F	----	24·32	24·46

$5TlF.3ZrF_4.H_2O$.—This salt crystallizes in needles when from one to three and one-half parts of thallium fluoride are added to one part of zirconium fluoride. When about four parts of thallium fluoride are added, the same salt crystallizes in a different habit, forming prisms of hexagonal outline which under the microscope are seen to be twinned, resembling in this respect the hexagonal-shaped crystals of aragonite. On recrystallizing, both habits give the needle-shaped crystals.

The following analyses were made of the two kinds of crystals. A rather large number of determinations was made on account of the existence of two different forms.

* By difference.

	Tl.	Zr.	H_2O.	F.
I	61·58	16·88	----	----
II	62·05	16·84	----	----
III	61·37	17·14	1·40	----
IV	61·58	16·88	1·17	19·31
V	61·74	17·04	1·42	----
VI	----	----	1·31	----
VII	62·91	16·42	----	----
Calculated for $Tl_5Zr_3F_{17}.H_2O$	62·47	16·58	1·11	19·84

$3TlF.ZrF_4$.—Crystals of this salt form in brilliant octahedra when one part of zirconium fluoride is added to from four to twenty parts of thallium fluoride. It is easily recrystallized.

The following analyses were made:

	I.	II.	Calculated for Tl_3ZrF_7.
Tl	72·82	73·20	73·24
Zr	10·91	10·38	10·80
F	15·65	----	15·96

Sheffield Chemical Laboratory, New Haven, January, 1897.

ART. L.—*Preliminary Note on the Broadening of the Sodium Lines by Intense Magnetic Fields;* by A. STC. DUNSTAN, M. E. RICE and C. A. KRAUS.

DR. P. ZEEMAN (Phil. Mag., March, 1897), using as a source of light a Bunsen flame between the poles of an electromagnet, has shown that the sodium lines are broadened by the influence of an intense magnetic field. To obtain the necessary dispersion he used a large concave grating.

It occurred to the writers that the interferometer invented by Michelson of Chicago University, being far more powerful than a grating for the purpose of analyzing a single line in the spectrum, ought to show the effect of magnetic influence more decidedly.

For this purpose the apparatus was arranged as shown in

1.

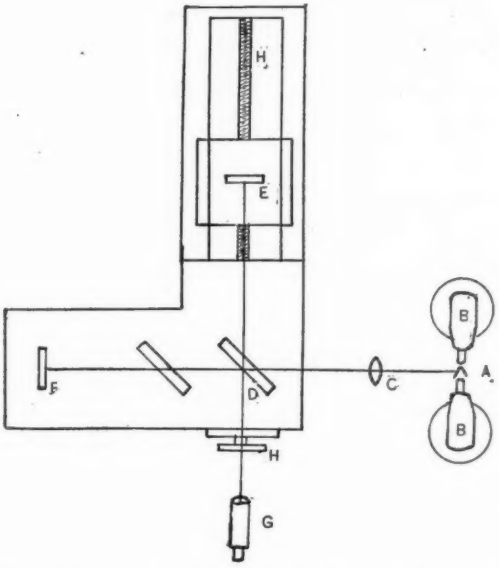


fig. 1. The light was furnished by a Bunsen flame A, placed between the poles of a powerful electromagnet B.

A piece of asbestos saturated with NaOH solution was wrapped around the burner at the top. The light is rendered slightly convergent by the lens C and falls upon the semi-

silvered surface D, where part is reflected to the movable mirror E and part transmitted to the fixed mirror F. These two beams are reflected and both finally enter the telescope G.

Under these conditions, with a telescope focussed for parallel rays or with the unaided eye, the observer will see a series of concentric circular fringes. If now the mirror E is moved away from the observer by turning the screw H, the difference of path of the interfering pencils is increased and the fringes become periodically more or less distinct or "visible," passing through successive maxima and minima.

The visibility is defined as the ratio between the difference of intensities of a bright and a dark ring divided by the sum of these intensities, or expressed algebraically,

$$V=\frac{I \text{ bright}-I \text{ dark}}{I \text{ bright}+I \text{ dark}}.$$

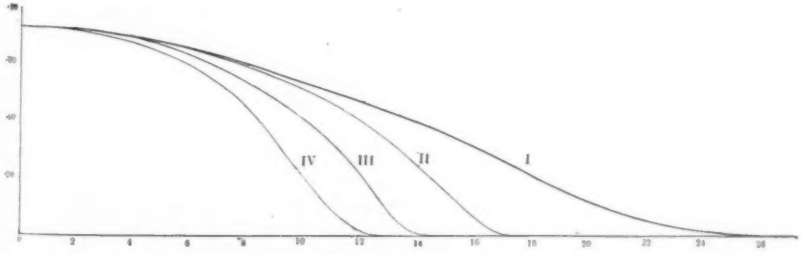
If now the visibilities at the maxima be observed for increasing differences of path, then the approximate equation of this curve is of the form $V=2^{-\frac{x^2}{\Delta^2}}$, where x is difference of path in mm., V is visibility as a proper fraction, and Δ is the difference of path at which V falls to half its initial value.

Now the half-width of either of the two sodium lines giving such a curve is given by $\delta=\frac{\cdot 22\lambda^2 . 10^7}{\Delta}$, where λ, Δ are in mm. and δ in Ång. units.

It is thus seen that the broadening of the two sodium lines would be indicated by a more rapid falling off in this visibility curve.

The curves obtained by the writers are shown in fig. 2. (I)

2.



is the visibility curve obtained as above from the Bunsen flame, the magnet not being excited; while (IV) is the visibility curve when the magnetic field between the pole pieces was

in the neighborhood of 3000 C. G. S. units (estimated). The other two curves were taken with weaker fields. The relative strengths of field were in the same order as the shortening of the curves.

It is thus seen that the two sodium lines are broadened by the most intense field about in the ratio of 1 to 1·7, and less with weaker fields.

The effect is very decided when a difference of path of 10 to 18^{mm} is reached. The fringes are quite distinct with no magnetic field but are almost entirely obliterated when the current is turned on.

No special adjustment of the apparatus is necessary beyond that ordinarily required to obtain clear fringes.

The visibilities given are uncorrected eye estimates, but the results are so decided that it seems worth while to record this confirmation of Zeeman's discovery.

The writers intend to carry out immediately a more careful set of measurements along this line and hope soon to be able to communicate a more accurate set of results.

Physical Laboratory,
University of Kansas, April 15th, 1897.

May 10th, 1897.

Since the above note was written we have determined the amount of broadening in Ångström units produced by various magnetic fields of measured intensities. Using fields ranging from 0 to 7800 C. G. S. units, we have found that the percentage broadening is directly proportional to the field strength; the absolute amount for sodium in a unit field is $11{\cdot}46 \times 10^{-6}$ Ångström units. By percentage broadening is meant the increase in width divided by the original width of the line.

These results are in accord with the electromagnetic theory of Lorentz as given by Zeeman (Phil. Mag., March, 1897).

Art. LI.—*The relative Motion of the Earth and the Ether;* by Albert A. Michelson.

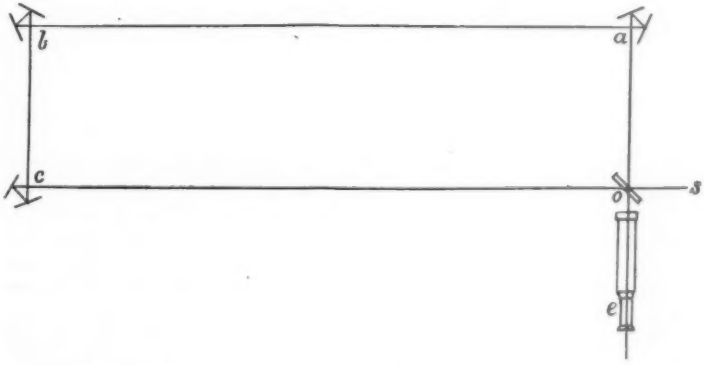
To account for the phenomenon of aberration Fresnel supposes the luminiferous ether at rest, the earth moving through this medium without communicating any perceptible part of its motion. On this theory it has been shown* that it should be possible to detect a difference of the velocity of light in two directions at right angles. As no such difference was observed, it would seem to follow that Fresnel's hypothesis is incorrect.

Another theory is that of Stokes, in which the aberration is accounted for if the relative velocity of the earth and the ether have a potential. This requirement, however, is inconsistent with the results of the experiment just cited, which indicates that at the earth's surface the relative motion is zero.

In the hope of detecting a relative motion corresponding to a difference of level, the following experiment was undertaken.

I take this opportunity of gratefully acknowledging the faithful and efficient services rendered in the execution of this work by Professor S. W. Stratton and Mr. C. R. Mann.

1.

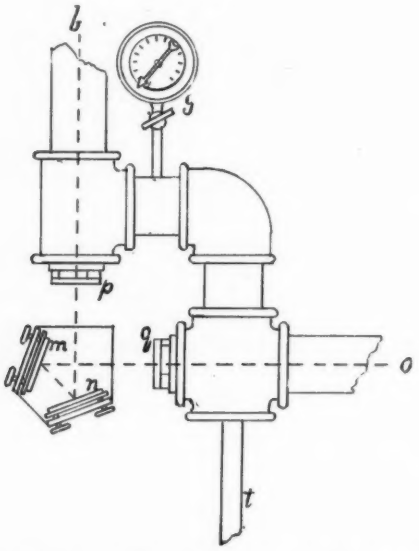


Light from the source *s*, a calcium light or an electric arc lamp, separated into two pencils at a plane-parallel glass plate, *o*, lightly silvered. The two pencils were reflected by double mirrors along the paths *oabcoe*, and *ocbaoe*, respectively. The two paths being equal, interference fringes could be observed with the aid of the telescope at *e*. Fig. 2 shows details of the corner at *c*: *pq* are plane-parallel glass disks, cemented to the

* This Journal, November, 1887.

ends of the iron pipes; *mn*, plane glass plates silvered on front surface, and provided with adjustments in two planes; *omnb*, the path of the pencil of light. The apparatus was set up in the vertical east and west plane, the light traversing the entire circuit of the Ryerson Laboratory, a path about 200 feet long and 50 feet high.

2.



It was found that under ordinary conditions the temperature disturbances in this length of air made it impossible to measure the position of the fringes; and the difficulty was only slightly remedied by enclosing the whole path of the light in a wooden box. By making this enclosure an iron pipe and exhausting the air to within a hundredth of an atmosphere, it was found possible to measure the position of the central bright fringe to within something like a twentieth of the fringe-width.

A difficulty is encountered in the selection of a fiducial mark. The double image of the source does not remain on the cross hairs of the observing telescope for any great length of time, notwithstanding the precaution of the double reflections at the corners, but by using this double image itself as the fiducial mark, any possible errors due to daily temperature changes, etc., are eliminated. This double image and the interference fringes are not in focus at the same time, but by sacrificing a very

little in the definition of each, the measurements may be made with very considerable precision.*

The observations were taken in the morning, at noon, evening and night; no special care being taken as to the exact hour. The results are summed up in the table containing the observations taken and reduced by Mr. Mann, as follows:—

The micrometer was set on one spot, then on the central fringe, then on the other spot, giving three readings of the micrometer. The first reading was subtracted from the third, giving the distance between the spots in divisions of the micrometer head. The second reading was subtracted from the third, giving the distance of the central fringe from the lower in divisions of the micrometer head. This last remainder was divided by the first, giving the distance n of the central fringe from the lower spot in fractions of the distance between the spots regarded as unity.

Each reading was reduced this way and the mean of ten taken as the result for any given time. The weights p were calculated as usual from the formula: $p = c/e^2$.

Date.	6 A. M.			12 Noon.			6 P. M.			11 P. M.		
	n	p	pn	n	p	pn	n	p	pn	n	p	pn
March 11	·500	67	33·50	·515	40	20·60	·503	12	6·03	·480	20	9·60
	·513	38	19·49				·506	10	5·06	·490	32	15·68
March 13	·495	11	5·44	·530	33	17·49						
March 16	·507	55	27·88	·499	50	24·95	·492	13	6·40	·479	60	28·74
	·509	120	61·08	·491	45	22·09	·488	40	19·52	·487	22	10·71
March 17	·490	40	19·60	·504	80	40·32	·500	35	17·50	·488	105	51·24
	·488	50	24·40	·502	60	30·12	·498	30	14·94	·496	100	49·60
March 18	·501	80	40·08	·492	80	39·36	·493	40	19·72	·498	25	12·45
				·507	50	25·35	·488	25	12·20	·498	35	17·43
Sums.		461	231·47		438	220·28		205	101·37		399	195·45
Means.		·502 ± ·002			·503 ± ·003			·494 ± ·002			·490 ± ·002	

12 Noon − 11 P. M. = ·013
1 fringe = ·250

∴ maximum displacement $\frac{13}{250} = \frac{1}{20}$ fringe.

The conclusion from these results is that if there is any displacement of the fringes it is less than one-twentieth of a fringe.

If we consider the times occupied by the two pencils in com-

* On account of the inequality of the angles of incidence and reflection there will be a slight difference between the real and apparent positions of the double image. This difference will be altogether too minute to produce any appreciable error. Again, this difference in direction produces a difference in the length of the two paths—which is however of the second order and can also be neglected.

pleting their paths at noon and at midnight (when the horizontal parts of the path are parallel with the earth's motion in its orbit), we find the difference is $4s\frac{v}{V^2}$ where s is the length of the horizontal part of the path, v, the *difference* of relative velocities above and below, and V the velocity of light. This corresponds to a *displacement* $\Delta = 4\frac{s}{\lambda}\frac{v}{V}$ fringes.

If the relative motion be assumed to follow an exponential law it may be represented by

$$v = v_0(1 - e^{-kh})$$

where v_0 is the velocity of the earth and h, the height above the surface.

Suppose $\frac{v_0 - v}{v}$ falls to $\frac{1}{e}$ of its surface value in one hundred kilometers. Then in fifteen meters, which is the difference of level of the two horizontal pipes

$$v_0 - v_1 = \cdot 00015\ v_0.$$

Substituting this for v in the equation for Δ we have

$$\Delta = \cdot 0006\ \frac{s}{\lambda}\frac{v_0}{V}.$$

Putting $\frac{s}{\lambda} = 12 \times 10^7$ and $\frac{v_0}{V} = 10^{-4}$ we find $\Delta = 7 \cdot 2$ fringes.

As the actual displacement was certainly less than a twentieth of a fringe, it would follow that the earth's influence upon the ether extended to distances of the order of the earth's diameter.*

Such a conclusion seems so improbable that one is inclined to return to the hypothesis of Fresnel and to try to reconcile in some other way the negative results obtained in the experiment cited in the first paragraph.

The only attempt of this character is due to H. A. Lorentz.† It involves the hypothesis that the length of bodies is altered by their motion through the ether.

In any case we are driven to extraordinary conclusions, and the choice lies between these three :—

1. The earth passes through the ether (or rather allows the ether to pass through its entire mass) without appreciable influence.

2. The length of all bodies is altered (equally ?) by their motion through the ether.

3. The earth in its motion drags with it the ether even at distances of many thousand kilometers from its surface.

* Of course this will depend on the law assumed for the rate of diminution of relative velocity with distance from the earth's surface; and possibly an exponential law is far from the truth. It may be desirable to repeat the experiment with a much greater difference of level, and perhaps to bury the lower tube some distance underground.

† "Versuch einer Theorie der El. u. Op. Erscheinungen in bewegten Körpern," H. A. Lorentz.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Relation of Refraction to Density.*—It is well known that Kopp distinguished between real and apparent molecular volume by defining the former as the space actually occupied by the molecule and the latter as this quantity increased by the space in which the molecule moves. Traube prefers to call the former the molecular nucleus-volume and the latter the molecular vibration-volume; the nucleus-volume being the sum of the atomic nucleus-volumes, and the vibration-volume being the sum of the atomic vibration-volumes, increased by the space in which the molecule itself vibrates. Hence for this molecular vibration-volume, which is the quotient obtained by dividing the molecular mass by the density, we have $V_m = \Sigma nC + Cov$; i. e., the sum of the products of the vibration-volumes of the separate atoms by their number, increased by the molecular co-volume, which is constant and has the value 25·9. In a previous paper the author had shown that the molecular co-volumes of liquids, and probably of solids also, are equal, so that the laws of Avogadro and Gay Lussac apply to these states of matter. While therefore the passage from the solid to the liquid state is not accompanied by any change in the molecular co-volume, this value decreases when the liquid becomes a gas, the decrease being greater the higher the temperature. Hence for every substance there must be a particular temperature at which the co-volumes of the liquid and the gas are the same. This obviously is the critical temperature. Traube has now shown that if, according to the Clausius-Mosotti dielectric theory, v be the space actually filled with matter, and k the dielectric constant, the molecules being supposed spherical, $v = (k-1)/(k+2)$. But the dielectric constant, on the electromagnetic theory of light, is equal to the square of the index of refraction μ for waves of very great length. Hence as Exner has proved $v = (\mu^2-1)/(\mu^2+2)$. Moreover as above stated, this value is comparable to the expression $\Sigma nC/V_m$; so that the quotient of $\Sigma nC/V_m$ divided by $(\mu^2-1)/(\mu^2+2)$ should be a constant quantity. From the tabulated results of a long series of calculated values of this ratio it appears that the atomic vibration-volume calculated from the molecular mass and the density are equal to the atomic nucleus-volumes, obtained from atomic refraction, multiplied by a constant which varies only with the wave length of light and this within narrow limits. For D, this constant is 3·44; for Cauchy's constant A, it is 3·53.—*Ber. Berl. Chem. Ges.*, xxix, 2732–2742, December, 1896. G. F. B.

2. *On the Properties of Free Hydrazine.*—According to Lobry de Bruyn, free hydrazine is best prepared by the action of barium oxide on hydrazine hydrate. The barium oxide is contained in a flask provided with a neck about 50^{cm} long bent at right angles

at its upper end so that it can be attached to the condenser directly. The hydrate is added in small quantities at a time, the mixture being kept cool during the action. The flask is heated for several hours in a glycerin bath at 110°–120° and the contents are then distilled under a pressure of 150–100^{mm}, the apparatus being filled with dry hydrogen to prevent oxidation. The base, which collects in the cooled receiver, still contains 3 or 4 per cent of water, from which it is freed by re-distillation with barium oxide. The free hydrazine fuses at 1·4°; though the liquid can be cooled several degrees lower before it freezes. Its boiling point, taken in dry hydrogen, is 56° at 71^{mm}, 113·5° at 761·5^{mm} and 134·6° at 1490^{mm} pressure. Its specific gravity at 15° is 1·014; about the same as that of the hydrate. In solubility hydrazine resembles both water and hydroxylamine. It is miscible in all proportions with methyl, ethyl, propyl, isobutyl and amyl alcohols. It combines with sodium chloride apparently, a considerable amount of heat being produced when these substances are mixed. They solidify to a crystalline mass on cooling. The base may be heated to 300°–350° without perceptibly decomposing; a portion remaining unchanged even after being heated for an hour to the boiling point of sulphur. The critical temperature of hydrazine is 380°. Its stability at high temperatures depends on the pressure, the decomposition at first being $(N_2H_4)_2 = N_2 + H_2 + (NH_2)_2$ but subsequently changing to $(N_2H_4)_3 = N_2 + (NH_3)_4$. Hydrazine is a strong reducing agent, readily bursts into flame in chlorine and reacts violently with bromine and iodine. It is slowly oxidized in dry air and in oxygen; the temperature in the latter case rising to 100°. Sodium acts on this base when suspended in light petroleum yielding hydrogen, ammonia, and a brown, solid substance.—*Rec. Trav. Chim.*, xv, 174; *J. Chem. Soc.*, lxxii, 22, Jan., 1897. G. F. B.

3. *On Nitrogen Pentasulphide.*—Nitrogen pentasulphide N_2S_5 has been obtained by Muthmann and Clever by heating the nitrogen sulphide N_4S_4 with pure carbon disulphide for two hours at 100° under a pressure of five atmospheres. A deep red solution containing a yellowish-brown, amorphous precipitate is thus obtained, which is filtered and the filtrate distilled until most of the carbon disulphide is removed. The residue is then allowed to evaporate in a vacuum at the ordinary temperature. A red, oily product results, which consists of a mixture of the pentasulphide with sulphur. This is treated with dry ether to remove the pentasulphide, the last traces of sulphur being crystallized out by means of a freezing mixture. The ether is allowed to evaporate, the last traces being removed over calcium chloride. After filtering, the red oil, if pure, crystallizes from a well-cooled etherial solution in tablets resembling iodine. The molecular mass determined cryoscopically, using benzene as the solvent, gave the formula N_2S_5. The amorphous bye-product already mentioned gave the formula $C_2N_2S_2$. It is a fine yellow powder, is extremely hygroscopic and retains strongly traces of carbon

disulphide and the pentasulphide. Concentrated sulphuric acid dissolved it unchanged, and it resembles somewhat pseudocyanogen sulphide $C_2N_2S_2H$. Nitrogen pentasulphide may also be formed by the action of nitrogen sulphide on carbon tetrachloride, or by reducing thiotrithiazyl chloride N_3S_4Cl suspended in methyl alcohol by means of zinc dust. In general it results from the decomposition of nitrogen sulphide and its derivatives; as for example when this substance is exploded by friction, when its compounds with the halogens or with nitrous or nitric acid are boiled with water, and when it is heated cautiously with lead oxide. Nitrogen pentasulphide is a deep red liquid, with a sp. gr. of 1·901 at 18°. It does not wet glass, is partially decomposed when distilled even under diminished pressure, and when cooled in a freezing mixture solidifies to a crystalline mass resembling iodine, which fuses at 10°–11°. It is insoluble in water, but dissolves in most organic solvents, its solution being stable when protected from light. Its absorption spectrum is characterized by a broad band extending from the D line into the blue. If a minute quantity of alcoholic potash or soda is added to its solution in alcohol, an intense violet-red coloration is produced transiently; this reaction serving to detect a very minute quantity.—*Zeitschr. anorg. Chem.*, xiii, 200–208, October, 1896. G. F. B.

4. *On the Direct Union of Carbon and Hydrogen.*—In Berthelot's experiments on the action of carbon on hydrogen at high temperatures, the only positive result obtained was the formation of acetylene when the electric arc was formed between carbon terminals in an atmosphere of hydrogen. Bone and Jordan have re-investigated this subject, using for the purpose two different methods. In the first a current of hydrogen was passed over carefully purified sugar-charcoal contained in a porcelain tube heated in a Fletcher furnace to about 1200°. While the issuing gas contained no acetylene or other unsaturated hydrocarbon, there was present invariably about one per cent of a saturated hydrocarbon, probably methane. In the second method an electric arc was formed between terminals of purified carbon in an atmosphere of hydrogen. The products obtained were acetylene and methane. Experiments on the progress of the reaction showed a somewhat rapid production of both gases during the first half hour, while the amounts formed subsequently seemed gradually to approach a limit. Since this condition of equilibrium between hydrogen, methane and acetylene is of great interest, the authors produced the arc in an atmosphere either of methane or of acetylene, expecting that while at first the greater part of the methane or acetylene would be decomposed, there would finally be reached a condition of equilibrium similar to that obtained in the experiment with hydrogen. This was found to be the case. The authors sum up their results as follows: (1) At a temperature of 1200° or thereabouts, carbon unites directly with hydrogen to form methane, no acetylene or other unsaturated hydrocarbon being formed at this temperature. (2) When the electric arc is

produced between carbon terminals in an atmosphere of hydrogen, methane and acetylene are both formed; on continuing the passage of the arc a state of equilibrium between hydrogen, methane and acetylene is finally established. (3) The same state of equilibrium is produced when the electric arc is passed in an atmosphere of either methane or acetylene under similar conditions.—*J. Chem. Soc.*, lxxi, 41–61, January, 1897. G. F. B.

5. *On the Preparation of Rubidium and its Dioxide.*—An improved process of obtaining metallic rubidium has been devised by ERDMANN and KÖTHNER, giving a yield of 85 per cent. Rubidium hydroxide, 20 grams, coarsely pulverized and mixed with ten grams of magnesium filings, is placed in the long arm of a seamless iron tube one meter long and 15^{mm} bore, having walls three millimeters thick, this tube being bent about 15^{cm} from one end at an angle of 125°. At the bend is placed a loose plug of clean steel turnings. The tube is placed in a combustion furnace and heated to redness while a current of hydrogen is passed through it. The short arm dips beneath the surface of some paraffin oil and as the temperature is gradually raised, the rapid escape of bubbles indicates that the reaction has begun. The heat is then shut off and after hydrogen ceases to be evolved from the hydroxide, the temperature is raised to a red heat and the metal distils over, 14 grams being obtained from the 20 grams of hydroxide used. The yield is very pure, the metal having a specific gravity of 1·5220 at 15° and a melting point of 38·5°. By the action of dry oxygen on the metal at the ordinary temperature, the dioxide is obtained. Since under these conditions, rubidium attacks glass, porcelain, platinum, silver and even rubidium chloride, the authors allow the metal to fall into an aluminum dish contained in a small glass flask filled with nitrogen; the whole being weighed both before and after the oxidation. When a current of oxygen is directed on the metal, it quickly melts and even inflames. With normal oxidation the metal preserves for a time the look of molten gold, then swells and becomes black and the absorption ceases. It is renewed however at 500°, the volume diminishes and a thick black liquid is produced, from which on cooling the dioxide crystallizes in dark brown plates. No evidence was obtained of any other oxide of rubidium, and this one may be highly heated without losing or taking up oxygen. Water acts on it violently, producing hydrogen peroxide and rubidium hydroxide, oxygen being evolved. Heated in an atmosphere of hydrogen, the dioxide yields the hydroxide, water and oxygen in accordance with the equation $(RbO_2)_2 + (H_2)_2 = (RbOH)_2 + H_2O_2$.—*Ann. Chem. Pharm.*, ccxciv, 55–71, November, 1896. G. F. B.

6. *On the Pyrogenic Reactions of Aliphatic Hydrocarbons.*—Experiments have been made by HABER on the action of high temperatures on aliphatic hydrocarbons, using for the purpose hexane, trimethylethylene, acetylene and benzene. By passing a current of the gas through a hot tube it was exposed to the high

temperature for a few seconds only and thus secondary reactions were avoided. He found that at 600° to 800°, neither carbon nor an appreciable amount of hydrogen was liberated, but that the actual change was a shifting of an atom of hydrogen, forming an olefine and either methane or ethane, the latter in the smaller quantity. Hexane yields amylene and methane, trimethylethylene gives methane also but ethylene in addition, a complete change of arrangement taking place. Thorpe and Young had noticed in 1873 that paraffin yields no hydrogen on distillation, but lower hydrocarbons, of nearly equal molecular mass. In the paraffins the union of carbon with carbon is thus more easily dissolved than the union of carbon with hydrogen. But with the aromatic hydrocarbons the opposite seems to be the fact, benzene for instance giving diphenyl and hydrogen; although its decomposition is more difficult than that of hexane. At 900° to 1000° however the pyrogenic reaction is quite different, coke, tar and hydrogen being formed, methane being the only resulting paraffin and ethylene the only olefine. Hence ethylene does not unite with hydrogen at this temperature. At 800° acetylene gives but little ethylene with much hydrogen. Methane is quite stable.—*Ber. Berl. Chem. Ges.*, xxix, 2691–2700, December, 1896. G. F. B.

7. *On the Explosive Properties of Acetylene.*—It has been shown by Berthelot and Vieille that when acetylene under ordinary pressure is exposed to the action of the electric spark, of a red hot wire, or of an explosion of fulminate, the gas is decomposed only in the immediate vicinity; while when the gas is under pressure the result is quite different, the gas showing the ordinary character of explosive mixtures when the pressure exceeds two atmospheres. In this case the explosion rapidly spreads through the entire mass of the gas, which decomposes into hydrogen and finely divided bulky carbon. If the initial pressure be 21 kilos. per square centimeter, the pressure developed is ten times this value, the change being complete in 0·018 of a second. Liquid acetylene decomposes in the same way. Using 18 grams in a bomb of 48·96^{cc} capacity, the final pressure was 5564 kilos. per sq. centimeter, almost the equal of gun cotton. Simple shock seems incapable of causing acetylene to explode either in the gaseous or liquid state. If water be made to act on excess of calcium carbide in a closed vessel, the elevation of temperature may be sufficient to start the decomposition of the whole of the compressed gas.—*C. R.*, cxxiii, 523–530, October, 1896. G. F. B.

8. *On the form of the atoms;* by C. Fourlinnie. Pamphlet, 8vo. Reims, 1896.—In this little work M. Fourlinnie has sought to solve the following problem: "Can we explain the properties of simple bodies by supposing that their atoms are composed of a single and homogeneous substance, but having geometrical forms which differ from one simple body to another?"

Limiting this investigation to the metalloids, the author arrives at the conclusion that the metalloids belonging to a single class according to Dumas possess atoms of the same form, but of dif-

ferent dimensions, while metalloids belonging to two different families have different atoms. Carrying this analogy further, M. Fourlinnie shows that these atomic forms ought to be regular polyhedrons; a conclusion perfectly in accord with the fact that only five regular polyhedrons exist, corresponding to the five families of Dumas.

For accomplishing this determination he is led to compare the volumes of different regular polyhedrons, and thus he finds that the volumes of the cube, the octahedron the dodecahedron and the icosahedron when circumscribed upon the same sphere are to each other as the numbers 19, 16, 14 and 12, which are respectively the atomic weights of fluorine, oxygen, nitrogen and carbon.

M. Fourlinnie is then naturally led to conclude that the simple bodies of the family of fluorine have cubic atoms; those of the family of oxygen octahedral atoms; those of the nitrogen family, dodecahedral; finally, those of the carbon family have atoms of the form of regular icosahedrons. By exclusion, the regular tetrahedron belongs to hydrogen. It results, further, that the simple bodies at the head of the columns, Fl, O, N, C, have atoms of the same apothem, a circumstance which arouses the hope that it will be possible, according to the prediction of M. Schutzenberger, to establish the decimals of the atomic weights by mathematical calculation.

After some interesting considerations upon the repulsive and attractive action of the atoms, the author examines the consequences of his theory from the point of view of the combination of atoms among themselves and of atomicity. When the atoms combine they assume a state of stable equilibrium when the axes, determined by the faces (apothems), or the summits are coincident to each other.

By aid of these considerations the double atomicity of oxygen easily explains itself. It is the same with the triple atomicity of nitrogen, and further, the coexistence of the atomicities 3 and 5 in this element receives a striking interpretation; in the first case the equilibrium is determined by the apothems, in the latter by the summits. For carbon the tetratomicity is more difficult; it necessitates an equilibrium partly according to the apothems and partly according to the summits.

The ingenious theories of M. Fourlinnie are certainly not beyond all criticism, but they recommend themselves, from their originality and their novelty, to the good will of the scientific world. They should be considered as the embryo of a novel theory which will perhaps throw a new light on the obscure question of the relations of the atomic weights to each other. It is probably the first time that there has been given a relation of a mathematical order between the numerical values of the atomic weights of the simple bodies at the head of the columns, fluorine, oxygen, nitrogen and carbon.—*From the French of G. Darzens, Bull. Soc. Chim.*, III, xv, 975. H. L. W.

9. *Use of rapid electrical oscillations for determining dielectric constants.*—W. NERNST describes a modification of his well-known bridge for determining dielectric constants. It is a species of double transformer. A spark gap is placed in the primary of one transformer. The bridge combination is connected to the terminals of the secondary of this transformer. In place of a telephone there is substituted the primary of the second transformer and a spark gap is placed in the secondary of the latter transformer. The extinction of the spark in this secondary denotes a balance. The apparatus is suitable for the measure of the dielectric constants of conducting fluids. Electrolytic resistances can also be determined to the fraction of one per cent; disturbances from polarization do not enter.— *Wied. Ann.*, No. 4, 1897, pp. 600–624. J. T.

10. *Ultra-red rays.*—H. RUBENS and A. TROWBRIDGE reach the conclusion that it is possible by means of a double spectral separation by the help of two acute angled prisms of rock salt to detect the energy of the spectrum as far as 18μ, and that with the aid of sylvine prisms it is possible to extend this limit to 23μ. — *Wied. Ann.*, No. 4, 1897, pp. 724–739. J. T.

11. *Production of X-rays of different penetrative values.*—Mr. A. A. C. SWINTON states that the penetrative value of the X-rays increases with the degree of vacuum in which they are produced. At a certain vacuum the bones of the hand, for instance, are clearly seen; with a higher vacuum the flesh becomes very transparent, while the bones are still opaque. At a still higher vacuum the bones become nearly as transparent as the flesh; and finally, at the highest vacuum the whole hand shows only a faint shadow on the fluorescent screen. Similar effects can be produced with a constant vacuum by varying the power of the Ruhmkorf coil or by altering the distance between the cathode and the anti-cathodes. On the assumption that cathode rays consist of regularly charged molecules which are repelled from the similarly electrified cathode, with an initial velocity that depends upon the degree of electrical excitation of the cathode, the conditions which produce X-rays of high penetrative value are those which would conduce to a high average velocity of the molecules at the moment they strike the anti-cathode and to a high average difference of potential between the travelling molecules and the anti-cathode at the moment of impact. The conditions for X-rays of low penetrative power are those which conduce to a lower average velocity of the molecules and to a less difference of potential between the latter and the anti-cathode. The quantity of X-rays is independent of the material of which the anti-cathode surface is made: anti-cathodes of aluminum, iron, copper, silver and platinum give X-rays of the same penetrative power.—*Nature*, April 29, 1897, p. 621. J. T.

12. *Physiological effects of the X-rays.*—M. SOREL discusses the pathological and physiological effects of the X-rays and believes that it is inadvisable to use the rays on portions of the human

body in the regions of important organs, like the heart or lungs. He finds a dead cold body more opaque to the rays than a dead body which is still warm. (Academy of Arts and Sciences, Paris, April 12.) W. Crookes, working on the same subject, believes that the physiological effects of the X-rays vary greatly with the idiosyncrasy of the experimenter; for he finds no injurious effects to himself even after prolonged exposure.—*Academy of Sciences*, Paris, April 20. J. T.

13. *Influence of magnetism on the nature of light emitted by a substance.*—Dr. P. ZEEMAN has observed that the spectral lines of sodium are broadened in a strong magnetic field.* Professor Lorentz's theory of the motions of ions in a magnetic field demands that the edges of the lines of the spectrum should be circularly polarized; the amount of widening can also be used to determine the ratio between charge and mass when a particle is giving out vibrations of light. Dr. Zeeman states that he has fully confirmed this theoretical deduction of Professor Lorentz by experiment.—*Phil. Mag.*, March, 1897, pp. 226–239. J. T.

14. *First Principles of Natural Philosophy;* by A. E. DOLBEAR, pp. 318, 12mo, Boston and London, 1897. (Ginn & Co.)—This little book contains a brief statement of physical principles and phenomena put in simple form for elementary students. A questionable feature of the work is the change of the usually accepted nomenclature of science in some respects, as where the word *pressure* is used for *force* in discussing energy and work.

I. GEOLOGY AND MINERALOGY.

1. *Congrès géologique international.*—A third circular, issued by the committee of organization of the geological congress to be held in Russia this summer, contains the following important information. Regarding the scientific program for the session of the congress, the committee announce as their opinion that, before taking up the other questions left undecided by previous sessions, the congress should decide which of these two classifications they desire to preserve in science, viz: the *artificial* classification, based entirely upon historical data, or the *natural* classification, which is based as much upon general physico-geographical changes, common to all the terrestrial globe, as upon faunistic data, and not upon the accidental limits of the different divisions, called after the name of the country where they have been first determined. The data upon which the science actually rests are sufficiently numerous for sketching the principal outlines of the great physico-geographic changes, such as transgression of the seas, the relations between these and general oscillations of the continents, the phenomena of dislocation, etc. The comparison of these data with the faunistic data will doubtless make it possible to introduce a new grouping of the geologic systems and to stop the continual fruitless polemics which arise from the efforts one is obliged to make to put all the new facts, which the

* See further p. 472 of this number.

diverse regions offer, into the framework of the actual systems. After the examination of these first points, it is greatly to be desired that a decision be reached on a second question of principle, viz: that of the rules to be followed in the introduction of new terms in *stratigraphic nomenclature*. Every one knows how new denominations for indicating the different geological divisions have been appearing in literature. Often the authors of the new terms introduce them without any argument, either petrographic or faunistic, which may serve to distinguish, in a clear manner, the sediments to which the denominations are applied from the neighboring deposits; it often happens that the authors themselves have a very vague notion of the criteria by which they apply the name. Such new terms evidently being only useless incumbrances to the science, it is greatly to be desired that the congress, which has already established rules to be followed in paleontological nomenclature, pronounce also on the question of stratigraphic nomenclature and that it establish the data upon which the application of new denominations to particular deposits be authorized.

Another question, considered to be of no less importance by the committee, is the determination of the principles to be applied in the application of *petrographic nomenclature*. The flood of new terms in this science has attained such dimensions, that soon no one's memory will be able to retain all and the reader of each memoir will be obliged to employ a special glossary. The works undertaken in this direction should be accomplished simultaneously with the deliberations regarding the principles of petrographic classification, the elaboration of which was entrusted by the congress of Zurich to a special commission under the presidency of M. A. Michel-Levy.

Regarding excursions, the committee announces an additional excursion to the *Tsëisky glacier*. The number of participants is restricted to 25 persons.

Excursion C to Finland will cost 130 francs, instead of 50 frcs. as previously announced.

In response to several letters recently received, the committee of organization finds it necessary to state that the passes (*billets gratuits*) over the Russian railroads will be good from July 22d to October 17th. The tickets will give to the geologists the right to pass from the frontier to the points of departure of the excursions (St. Petersburg, Moscow, etc.) and to take part in all the parts of the itineraries of the proposed excursions. They will also be valid for the return of the excursionists to the frontier from whatever point they may choose to leave the excursions.

The committee receives daily requests for admission to the excursions on the part of students of special high schools and of foreign universities. While appreciating the benefit the excursions would be to these young men, the committee finds itself, to its deep regret, unable to admit students, either foreign or Russian, to the excursions, on account of the great number of geolo-

gists who have already inscribed themselves as members of the congress, and because the number of persons who can participate in the excursions is necessarily restricted. H. S. W.

2. *Geological Survey of Canada.*—Three new Reports have appeared: viz.—

No. 584. Part L. Annual Report, vol. viii.—Report on explorations in the Labrador Peninsula along the East Main, Koksoak, Hamilton, Mamcaugan and portions of other rivers in 1892–93–94–95, by A. P. Low. pp. 1–387, four plates and four map sheets (585, 586, 587, 588).

No. 601. Part D. Ann. Rept., vol. viii.—Report on the country between Athabasca Lake and Churchill River, etc., by J. Burr Tyrrell assisted by D. B. Dowling; pp. 1–120, three plates and map sheet (597).

No. 615. Paleozoic Fossils, vol. iii., Part iii.—The fossils of the Galena-Trenton and Black River formations of Lake Winnipeg and its vicinity, by J. F. Whiteaves. pp. 129–242, plates xvi–xxii.

Mr. Low's Report on the Labrador peninsula is a particularly complete report on this little known region. In the opening pages a summary account is given of previous discoveries and explorations. Notes on the climate and population are given in addition to the description of the physical and geological characters of the district traversed. Appended to the report are Lists of the Mammals,—of the Birds,—of the principal Food Fishes,—of the Insects of the interior,—notes on the microscopic structure of rocks,—a list of plants and meteorological observations in 1893–1894 and 1895.

Mr. Whiteaves' Report on the Lake Winnipeg Ordovician forms contains the following remarks upon the gigantic size of fossils of this region:

"One of the most striking features in the fossils of the Winnipeg and Red River limestones is the large size to which many of the specimens attain, though this is more particularly the case with the Cephalopoda. Thus, one of the Receptaculitidæ (*Receptaculites Oweni*), which is abundant in these limestones, is known to attain to a size of twelve or even twenty inches in diameter. Some specimens of a simple Cyathophylloid coral (*Streptelasma robustum*) from Lower Fort Garry are nearly seven inches in length, as measured along the convex curve, and nearly five inches in height. A brachiopod from the same locality (*Rafinesquinalata*) is rather more than three inches in length at the hinge line, and a specimen of *Strophomena incurvata* from East Selkirk is fully double the usual size of that species. One of the gasteropods (*Maclurea Manitobensis*) of these limestones is sometimes as much as eight inches and a half in diameter, and another, (the *Hormotoma Winnipegensis* of this Report) is eight inches long. The "gigantic Orthoceratites" noticed by Sir John Richardson on the west side of Lake Winnipeg, have already been referred to, but these are from localities north of the Saskatchewan.

South of that river, at Dog Head, specimens of Orthoceratites" (probably of *Endoceras subannulatum*), four feet and a half or even six feet in length, and imperfect at both ends, were observed by Mr. Lambe in 1890. A siphuncle of *Endoceras crassisiphonatum*, which is also imperfect at both ends, is nearly three feet long. A specimen, which appears to be a cast of the anterior end of the body chamber of a specimen of a *Poterioceras* (probably *P. nobile*), recently collected by D. B. Dowling and L. M. Lambe at Berens Island, and showing the infolding of the lip, is seven inches across. Rough casts of the interior of spirally coiled discoidal or nearly discoidal shells, apparently allied to *Barrandeoceras*, from several localities on the west shore of Lake Winnipeg, are nearly or quite two feet across. Lastly, a free cheek of a trilobite, *Asaphus* (*Isotelus*) *gigas*, from Cat Head, indicates a specimen that must have been twenty inches in length when alive; and other similar examples could be given."

3. *A guide to the fossil invertebrates and plants in the department of geology and palæontology in the British Museum* (*Natural History*); pp. 1–158, figs. 1–182, 1897.—This guide, though of local value, primarily, is an admirable presentation of the most conspicuous features of fossil invertebrates, and the diagrammatic figures are selected with a view to make clear the distinctive characters of the several types of organisms, so as to be useful to one examining any well-equipped museum.

4. *The sea mills of Cephalonia;* by F. W. Crosby and W. O. Crosby; "Technology Quarterly," vol. ix, no. 1, pp. 6–23. The authors give a geologist's account of the famous sea mills near Argostoli, based upon personal examination. They associate the disposal of the downward-flowing waters with the formation of extensive and deep-seated fissures by earthquake, the return exit of which is supposed to appear in the numerous thermal springs of the region.

5. *Geologischer Wegweiser durch das Dresdner Elbthalgebiet zwischen Meissen und Tetschen;* von Dr. R. Beck; pp. 1–162 and maps. (Gebrüder Borntraeger) Berlin, 1897.—This is a handy pocket guide for geologists or mineralogists who may be spending the summer in the neighborhood of Dresden.

6. *Lawsonite.*—The new species lawsonite, described in 1895 by Ransome from Tiburon, Marin Co., California, has recently been identified by Franchi and Stella in the metamorphic rocks of the Piedmont Alps. It was first observed in an altered diabase near Elva in the Val Maira and since then it has been found to occur not infrequently in veinlets in a sodic amphibolite from the valley of Chianale. Its origin is regarded as similar to that of the epidote and zoisite common in the greenstones of the Alps.—*Bull. Soc. Min.*, xx, 5.

7. *A preliminary report on the Corundum deposits of Georgia.*—The administrative report of the State Geologist of Georgia, Mr. W. S. Yeates, was issued not long since, and with this were distributed Bulletin No. 1, a Preliminary Report on the Marbles

of Georgia by S. W. McCallie (previously noticed in the Journal), and Bulletin No. 2, giving a Preliminary Report on the Corundum Deposits of Georgia, by Francis P. King. This latter report, after a general account of the characters of the species and associated minerals, discusses at some length the special corundum deposits of Georgia. It will be found by all interested of much value as bringing together many facts and observations on the general subject with, further, a considerable amount of new matter.

III. Botany.

1. *Practical Botany for Beginners;* by F. O. Bower, F. R. S., Regius Professor of Botany in the University of Glasgow. Macmillan and Co., London, 1894.

Guide to the Study of Common Plants, an Introduction to Botany; by Volney M. Spalding, Professor of Botany in the University of Michigan. D. C. Heath and Co., Boston, 1895.

The Elements of Botany; by Francis Darwin, F. R. S., Reader in Botany in Cambridge University. University Press, Cambridge (England) 1895.

Elements of Botany; by J. Y. Bergen, A. M., Instructor in Biology, English High School, Boston. Ginn and Co.. Boston, 1896.

Laboratory Practice for Beginners in Botany; by William A. Setchell, Ph.D., Professor of Botany in the University of California. The Macmillan Company, New York, 1897.

Lessons in Elementary Botany for Secondary Schools; by Thomas H. MacBride, State University of Iowa. Allyn and Bacon, Boston, 1896.

In the list given above, we have enumerated a few of the latest works for beginners in Botany, not forgetting that there are earlier books on the same subject, or some aspects of it, which are by no means yet out of date. In such longer list would appear the names of many authors whose efforts in behalf of sound botanical training have yielded good results; results which have, in fact, been so good that some persons might be tempted to ask a few questions regarding the necessity of these newer handbooks. But, of course the answer is perfectly simple; every instructor has, or should have, decided views as to the best method of presenting the subject, and especially as to the best plan for beginning work. It is therefore of advantage to have a multiplicity of elementary treatises, provided they are not misleading: by inspection of these the teacher of beginners can compare different methods and select for his own pupils the one which comes nearest to his own ideal. We do not mean to say that all possible methods are likely to find their way into print, but we do think that at least some of the best are sure to be published. Further, we think that the handbooks heading this notice will, if taken in conjunction with a few others which will naturally

occur to the reader, and which are probably already in his hands, cover the chief types of dogmatic teaching and of laboratory work in Botany. Confining our notice to the half dozen here mentioned, we may say that the order in which they are arranged, although substantially chronological, represents a scale of decreasing difficulty and diminishing scope. In their respective works, Professor Bower and Professor Spalding seek to lead the student over a very large field of morphological and histological study, leaving little to be done as preliminary to special botanical research. Professor Bower's book is a trifle more technical in its treatment: Professor Spalding devotes rather more attention to matters of relationship.

The works by Mr. Darwin and Mr. Bergen are essentially of one type. They deal with the elements of morphology, histology, and physiology, drawing the mind of the pupils very early in the direction of habits. Mr. Bergen's handbook has also a short account of the most common plants of the northern and middle States, as a sort of introduction to work with some manual or flora.

The works by Professor Setchell and Professor MacBride form a third category. These are distinctly more elementary than the foregoing, both in scope and treatment, the latter being the simpler of the two. Both give much attention to morphology, to habits, and to adaptations. They discard the use of the compound microscope, and make the studies depend, where this is necessary, on the simple lens. With these six excellent types before us, it is difficult to see where a new handbook could find a place. Certainly, with these and with the earlier handbooks, every teacher of botany in our secondary schools ought to be able to put himself and his classes in possession of an acceptable manual adapted to the particular case. G. L. G.

IV. Miscellaneous Scientific Intelligence.

1. *Researches on the Evolution of Stellar Systems. Vol. I. On the Universality of the Law of Gravitation and on the Orbits and General Characteristics of Binary Stars;* by T. J. J. See. pp. 258, 4to. Lynn, Mass., 1896. — Mr. See's volume is attractive from its elegant and carefully finished form, while its fullness of detail in all matters relating to double stars makes it a most useful hand-book. Its value consists, however, not chiefly in its statistics, valuable as these are, but in the use which the author makes of statistics for theoretical research, and for the emphasis with which he presents the claims of the astronomy of binaries to a place of the first importance.

The processes of weighing and measuring which are well nigh brought to completion within the solar system have scarcely begun among the infinities of space and matter beyond its limits. Unless some means can be found to advance from these beginnings until columns become volumes, the prospect of carrying any

researches in cosmogony beyond the present stage of surmise and unverified speculation seems hopeless. The clearest line of progress for the immediate future appears to be among the binaries. The forty definite orbits, which represent the work of a century since Herschel, furnish the basis for considerable safe generalization, and their number is likely soon to be materially increased from the long list of close doubles discovered by Burnham and others, among which there should be many cases of rapid motion.

Mr. See develops very simply a method, based on the hodograph, whereby motion in the line of sight can be very effectively employed to determine the linear dimensions, mass and distance of a binary independent of parallax. The range of this method is limited only by the resolvability of the pair. Parallax reaches to about 20 light years, the latter method to 2000.

The best example of Mr. See's ability to make statistics fruitful is seen in his discussion of the eccentricity of binary orbits. That this is usually large, every astronomer knows. (The average for 40 orbits is 0·48) but no one has hitherto emphasized the fact that this corresponds to a physical cause necessarily of prime importance. A suggestion by the late Professor Kirkwood made in this Journal as early as 1864 is, so far as the present writer is aware, the only word previously spoken on the subject. Mr. See's explanation is, briefly, that the primitive orbit was of small eccentricity, as under the controlling influence of a centrifugal tendency in a tolerably homogeneous mass it might be expected to be, but that the enormous tidal friction which must arise in a binary system would produce perturbations so great as to push the eccentricity even to the limit of unstable equilibrium. Tides of such efficiency require that the component masses should be of the same order of magnitude. This is true without exception in all known orbits. The next volume will perhaps deal more particularly with the effects of tidal disturbances acting under these conditions. W. B.

2. *Annals of the Astronomical Observatory of Harvard College.*—Recent publications are the following: Vol. xxxvi. Journal of the Zone Observations of Stars between 49° 50′ and 55° 10′ of North Declination in 1855.0 and observed with the Meridian Circle during the years 1875 to 1885, under the direction of Joseph Winlock and Edward C. Pickering, Successive Directors of the Observatory; by William A. Rogers, 1896.

Also vol. xxviii, Part I., Spectra of Bright Stars photographed with the 11-inch Draper Telescope as a part of the Henry Draper Memorial and discussed by Antonia C. Maury under the direction of Edward C. Pickering, Director of the Observatory.

3. *Geographische Abhandlungen.* Herausgegeben von Prof. Dr. Albrecht Penck in Wien.—To the geographical memoirs edited by Prof. Penck in Vienna have been added the following: Volume v, No. 5, is devoted to a paper on the precipitation in Bohemia by Dr. Vasa Ruvarac, and one on the evaporation and flow from large surfaces of land, by Prof. Penck. Volume vi,

No. 1, discusses the features of the beautiful lakes of the Salzkammergut, and the Austrian Traun by Dr. Johann Müllner. This paper serves as an explanation to accompany the first part of the Atlas of the Austrian Lakes.

4. *Beiträge zur Geophysik: Zeitschrift für physikalische Erdkunde.* Herausgegeben von Prof. Dr. GEORG GERLAND. III Band, 1 Heft, Leipzig (Wilhelm Engelmann. 1896.) This first part of volume iii contains a series of valuable memoirs. From one of them, devoted to the *Aurora Australis*, we quote the accompanying figure showing the distribution of the southern

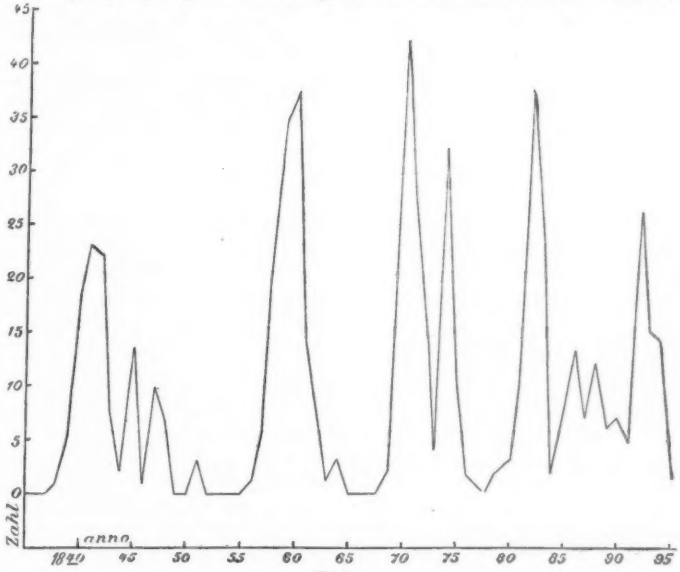


Fig. 1.

aurora during the years from 1835 to 1895. It is interesting as bringing out clearly the ten-to-eleven-year period which has been so well established for the northern aurora. This article gives an interesting discussion of the general subject of the *Aurora Australis* with the enumeration of many observations.

5. *Lavori esequiti nell'Instituto di Fisica dell'Università di Pisa, diretto dal* Prof. A. BATTELLI (Anno Scolastico, 1895–6), vol. i, pp. 214. Pisa, 1896.—This volume contains researches carried out in the Physical Institute of the University of Pisa, being reprints from Il Nuovo Cimento, of which Professor Battelli is one of the editors. Of the sixteen papers which it contains, three are by Professor Battelli alone and five are in conjunction with Dr. Garbasso, all of the latter having reference to the Röntgen rays. They constitute very valuable contributions to this interesting subject. An experiment given by Garbasso to show the dif-

ferences in the dielectric constant is simple and ingenious. The two plates of an Epinus condenser, somewhat separated, are connected, the one with a charged Leyden jar, the other with a gold leaf electroscope. On placing various dielectrics between the plates, the divergence of the leaves increases in proportion as the dielectric constant is greater. G. F. B.

6. *Ostwald's Klassiker der exakten Wissenschaften.*—The following additions have been made to this valuable series of scientific classics:

Nr. 80. Theorie der Luftschwingungen in Röhren mit Offenen Enden von H. Helmholtz. (1859.) 132 pp.

Nr. 81. Experimental-Untersuchungen über Elektricitat von Michael Faraday. 1 und 11 Reihe. (1832.) 96 pp.

Nr. 82, 83. Systematische Entwicklung der Abhängigkeit geometrischer Gestalten von einander, mit Berücksichtigung der Arbeiten alter and nener Geometer über Porismen, Projections-Methoden, Geometrie der Lage, Transversalen, Dualität, und Reciprocität, etc., von Jacob Steiner. I Theil., 126 pp., II Theil., 162 pp.

7. *La cause première d'après les données expérimentales;* by Émile Ferrière; pp. 462. (Paris: Felix Alcan, 1897.)—In two previous works the author has reached the conclusions that there is a unity to the laws of matter and energy throughout the universe; a substantial identity of matter and energy; a unity of life in plants and animals; the soul ("l'Ame") is the function of the brain. In the present work, he completes the series of his investigations, which he has undertaken in the spirit of Claude Bernard, and reaches the conclusion that there is one substance, the exterior manifestation of which is matter-energy. When this permanent source or substance is viewed from the point of view of truth, it takes the name of primary cause; when viewed from the point of view of the real, it is the world. In discussing these metaphysical points the author gives an elaborate synopsis of the creation of the animal and of the vegetable kingdom.

8. *Den Norske Nordhavs-Expedition 1876–1878.* Christiania, 1896.—Part XXIII of the seventh volume of this most valuable work, devoted to the results of the Norwegian North Atlantic Expedition, has recently been issued. It contains the following papers on the Tunicata: 1. Synascidiæ. 2. Ascidiæ Simplices og Ascidiæ Compositæ. 3. Fortegnelse over Norges Ascidiæ Simplices. 4. Om Knopskydningen hos Distaplia Magnilarva og Pyrosoma Elegans. 5. Kimbladstudier paa Grundlag af Ascidiernes Udvikling. Christiania, 1896: Grondahl & Sons.

INDEX TO VOLUME III.*

A

Academy, National, Washington meeting, 426.
Adams, F. D., Grenville and Hastings series of Canadian Laurentian, 173.
Alabama, report of the valley regions, McCalley, 350.
Ames, J. S., Theory of Physics, 420.
Argon, spectra of, Trowbridge and Richards, 15.
Astronomical Observatory, Harvard College, Annals, 252, 492.

B

Bacteria and decomposition of rocks, Branner, 438.
Bailey, L. H., Survival of the Unlike, 77.
Barlow, A. E. Grenville and Hastings series of Canadian Laurentian, 173.
Barnes, C. R., analytic keys to N. American mosses, 354.
Barus, C., interferential induction balance, 107; excursions of a telephone diaphragm, 219.
Bascom, F., volcanic rocks of South Mt., Penn., 160.
Battelli, H., physical papers from the Univ. of Pisa, 493.
Battery, large storage, Trowbridge, 246.
Becker, G. F., rock differentiation, 21; method of computing diffusion, 280.
Beecher, C. E., natural classification of the trilobites, 89, 181.
Bergen, J. Y., Elements of Botany, 490.
Botanical Works and Papers—
  Analecta Algologica, III, Agardh, 78.
  Ascomyceten, Früchtentwickelung, Harper, 78.
  Berberitze, Hexenbesenrost der, Eriksson. 353.
  Botany, Elements of, Bergen, 490; Darwin, 490.
    Laboratory practice for beginners, Setchell, 490.
Botanical Works and Papers—
  Botany, Lessons in Elementary, MacBride, 490.
    Practical for Beginners, Bower, 490.
  Cyperaceæ, Holm, 121, 429.
  Flora of Newfoundland, Robinson and von Schrenk, 77.
    of Northern United States, Canada, etc., Britton and Brown, 76.
    of Southern U. S., Chapman, 425.
  Flowering Plants and Ferns, Willis, 353.
  Index Desmidiacearum, Nordstedt, 354.
  Mosses, keys to N. American, Barnes and Heald, 354.
  Phycotheca Boreali-Americana, Collins, Holden and Setchell, 78, 354.
  Plants, Guide to the Study of Common, Spalding, 490.
  Protrophie, Minks, 355.
  Sphagna Boreali-Americana exsiccata, Eaton and Faxon, 77.
  Survival of the Unlike, Bailey, 77.
Branner, J. C., phosphate deposits of Arkansas, 159; bacteria and decomposition of rocks, 438.
Britton, N. L., Flora of the Northern United States, Canada, etc., 76.
Brown, A., Flora of the Northern United States, Canada, etc., 76.
Bush, K. J., Ledidæ and Nuculidæ of N. Atlantic coast, 51.

C

Cadmium normal element, Jaeger and Wachsmuth, 71.
Cajori, F., History of Elementary Mathematics, 79.
Canada, geol. survey, 72, 421, 488.
Case, E. C., foramina in cranium of a Permian reptile, 321.
Cell in Development and Inheritance, Wilson, 161.
Chalmers, R., Pleistocene glaciation in New Brunswick, etc., 72.
Chapman, A. W., Flora of the Southern United States, 425.

* This Index contains the general heads, Botany, Chemistry (incl. chem. physics), Geology, Minerals, Obituary, Rocks, and under each the titles of Articles referring thereto are mentioned.

CHEMICAL WORKS—
Chemie, Lehrbuch der Allgemeinen, Ostwald, 357.
Chemique Méchanique, Duhem, 419.
Chemistry, Tutorial, Bailey, 357.
Inorganic Chemical Preparations, Thorp, 357.
Chemistry, Laboratory Manual, Williams, 357.
CHEMISTRY—
Acetic series, fractional distillation of acids of, Sorel, 70.
Acetylene, explosive properties, Berthelot and Vieille, 483.
Alkali metals, spectra of fused salts, De Gramont, 150.
Argon, spectra of, 15.
Argon and helium, Lockyer, 152; electric discharge in, Collie and Ramsay, 241; density of, 241.
Cæsium and rubidium, double halogen salts, Wells and Foote, 461.
Carbon and hydrogen, direct union, Bone and Jordan, 481.
Crookes vacuum, boiling points, Krafft and Weilandt, 67.
Crystals, rotation of circularly polarizing, Landolt, 416.
Electrolysis of water, Sokoloff, 149.
Electrolytes, conductivity of, 391.
Electrolytic production of hypochlorites and chlorates, Oettel, 149.
Gold, experiment with, Lea, 64.
Helium, density, Ramsay, 241. See *Argon*.
Hydrazine, properties of free, de Bruyn, 479.
Hydrocarbon, new, Schickler, 70.
Iodic acid in analysis of iodides, Gooch and Walker, 293.
Iodine and bromine solutions, absorption spectra, Wood, 67.
Lead and bismuth in zinc, solubility, Spring and Romanoff, 418.
Lithium, preparation, Warren, 243.
and beryllium, Borchers, 151.
Metallic hydroxides, preparation by electrolysis, Lorenz, 244.
Metals, diffusion, Roberts-Austen, 147.
"excited," Wislicenus, 244.
Molybdenum, estimation iodometrically, Gooch, 237.
Nitrates in the air, Defren, 418.
Nitrogen gas, oxidation, Rayleigh, 416.
pentasulphide, Muthmann and Clever, 480.
Nitrous acid, action in a Grove cell, Ihle, 150.
CHEMISTRY—
Optical rotation in the crystalline and liquid states, Traube, 148.
Persulphuric acid, formation, Elbs and Schönherr, 68.
Pyrogenic reactions of aliphatic hydrocarbons, Habor, 482.
Refraction to density, relation of, Traube, 479.
Rubidium and its dioxide, Erdmann and Köthner, 482.
Silver oxide, reaction upon hydrogen peroxide, Riegler, 69.
peroxynitrate, Sulc, Mulder, and Heringa, 69.
Uraninite and eliasite, gases obtained from, Lockyer, 242.
Zirconium with lithium, etc., double fluorides, Wells and Foote, 466.
Christiansen, C., Theoretical Physics, 419.
Clark, W. B., Eocene deposits of middle Atlantic slope, 250.
Clarke, F. W., Constants of Nature, 245.
Climate of Davis' and Baffin's Bay, Tarr, 315.
of Frankfurt a M., Ziegler and König, 358.
Constants of Nature, Clarke, 245.
Crater Lake, Oregon, Diller, 165.
Crosby, W. O., geology of Newport Neck and Conanicut Island, 230.
Currents, rapid break for large, Webster, 383.

D

Darton, N. H., catalogue of contributions to North Amer. geology, 1732–1891, 350.
Darwin, F., Elements of Botany, 490.
Day, H. D., magnetic increment of rigidity, 449.
Diffusion of rocks, Becker, 21; method of computing, Becker, 280.
Diller, J. S., geological reconnaissance of northwestern Oregon, 155; Crater Lake, Oregon, 165.
Discharge rays, relation to cathode and Röntgen rays, Hoffmann, 246.
Dolbear, A. E., Natural Philosophy, 486.
Duff, A. W., seiches on the Bay of Fundy, 406.
Duhem, P., Méchanique Chemique, 419.
Dunstan, A. St. C., broadening of the sodium lines, etc., 472.

E

Earth and ether, relative motion of, Michelson, 475.
Eclipse Party in Africa, Loomis, 80.
Electric conductivity of the ether, Trowbridge, 387.
fields, rotation in constant, Quincke, 71.
light in capillary tubes, Schott, 152.
oscillations for determining dielectric constants, Nernst, 483.
waves, compact apparatus for the study, Bose, 245.
interferential refractor, Wiedeburg, 71.
Electricity, does a vacuum conduct? Trowbridge, 343.
and magnetism, Perkins, 246.
Electrolytes, conductivity of, Richards and Trowbridge, 391.
Ells, R. W., Grenville and Hastings, series of Canadian Laurentian, 173.
Ether, electrical conductivity of, Trowbridge, 387.
relative motion of earth and, Michelson, 475.

F

Ferrière, E., La cause première, 494.
Flotation of disks and rings of metals, Mayer, 253.
Foote, H. W., rœblingite from Franklin Furnace, N. J., 413; wellsite, a new mineral, 443; double halogen salts of cæsium and rubidium, 461; double fluorides of zirconium with lithium, etc., 466.
Foote, W. M., meteoric iron, Sacramento Mts., New Mexico, 65.
Fox Islands, Me., geology, Smith, 161.
Frazer, P., determination of minerals, 162.

G

Gases, multiple spectra of, Trowbridge and Richards, 117.
temperature and ohmic resistance, Trowbridge and Richards, 327.
Geologic Atlas of Yellowstone National Park, 246.
Geological congress, International, 351, 487.
Institute of Mexico, Bulletin, Aguilera, 422.
Geological Reports and Surveys—
Alabama, 1896, 350.
Canada, 72, 421, 488.
Georgia, 489.
Minnesota, vol. iii, part 2, 349.
United States, 17th annual, 153; report of director, Walcott, 249.
Geological Society of America, meeting at Washington, 156.
Géologiques, Catalogue des Bibliographies, de Margerie, 250.
Geologische Uebersichtskarte der Schweiz, Schmidt, 160.
Geology, catalogue of N. Amer. contributions, 1732–1891, Darton.
Elementary, Tarr, 351.
Introduction to, Scott, 422.
Geology—
Acid dike in Connecticut Triassic, Hovey, 287.
Arctic Sea ice as a geological agent, Tarr, 223.
Arkansas Valley, Colorado, underground water, Gilbert, 156
Bowlders of the Mattawa Valley, scoured, Taylor, 208.
Cephalonia, sea mills of, Crosby, 489.
Coals of Missouri, age of the lower, White, 158.
Crater Lake, Oregon, Diller, 165
Devonian formations of Southern U. S., Williams, 393.
Eocene deposits of the Middle Atlantic slope, Clark, 250.
Fault at Jamesville, N. Y., Schneider, 458.
Fauna of the Ithaca group, relation of, Kindle, 159.
Flore des couches permiennes de Trienbach, Zeiller, 74.
Foramina in cranium of a Permian reptile, Case, 321.
Fossil invertebrates and plants in British Museum, 489.
Fossils, vertebrate, of the Denver basin, Marsh, 349.
Geological reconnaissance in Oregon, Diller, 155.
Geology of Castle Mt. district, Montana, Weed and Pirsson, 250.
of Fox Islands, Maine, Smith, 161.
of Newport Neck and Conanicut Island, Crosby, 230.
of Santa Catalina Island, Smith, 351.
of southwestern Washington, Russell, 246.
Glacial ice, "plasticity," Russell, 344.

GEOLOGY—
Hesperornis, affinities of, Marsh, 347.
Laurentian, Canadian, Adams, Barlow and Ells, 173.
Leitfossilien, Koken, 160.
Lingulepis, Walcott, 404.
Man, antiquity, in Britain, Abbott. 158.
Phosphate-deposits of Arkansas, Branner, 159.
Pleistocene glaciation in New Brunswick, etc., Chalmers, 72.
Pre-Cambrian rocks and fossils, 157.
Rock differentiation, Becker, 21.
Stylinodontia, Marsh, 137.
Trilobites, classification of, Beecher, 89, 181.
See also ROCKS.
Gibbs, J. W., Hubert Anson Newton, 359.
Gilbert, G. K., underground water of Arkansas Valley, Col., 156.
Glaciers of N. America, Russell, 423.
Glycogen, Formative Property of, Creighton, 426.
Gooch, F. A., estimation of molybdenum iodometrically, 237; iodic acid in the analysis of iodides, 293.

H

Heald, F. DeF., analytic keys of North American Mosses, 354.
Hintze, C., Mineralogy, 251.
Holm, T., Cyperaceæ, 121, 429.
Hovey, E. O., acid dike in the Connecticut Triassic, 287; pseudomorphs after halite, Jamaica, 425.

I

Induction balance, interferential, Barus, 107.

J

Jaggar, T. A. Jr., instrument for inclining a preparation in the microscope, 129.

K

Kemp, J. F., Handbook of Rocks, 76.
Koken, E., die Leitfossilien, 160.
Kraus, C. A., broadening of the sodium lines, etc., 472.

L

Lea, M. C., experiment with gold, 64. Obituary notice of, 428.
Limestone of Jamaica, yellow, Hill, 251.
Lindgren, W., granitic rocks of Pyramid Peak, Cal., 301.
Loomis, E. J., Eclipse party in Africa, 80.

M

Magnetic increment of rigidity, Day, 449.
Magnetism, influence on light, Zeeman, 486; Dunstan, Rice and Kraus, 472.
Mammals, Catalogue of, Trouessart, 351.
Marsh, O. C., the Stylinodontia, 137; affinities of Hesperornis, 347; vertebrate fossils of Denver basin, 349.
Mathematics, History of Elementary, Cajori, 79.
Mayer, A. M., flotation of disks and rings of metal, 253.
Merrill, G. P., Treatise on Rocks, 423.
Meteor of Dec. 4, 1896, 81.
Meteorite, iron, Sacramento Mts. N. Mexico, Foote, 65.
Meteorites, in British Museum, Fletcher, 424; in Peabody Museum, Yale University, 83.
worship of, Newton, 1.
Meteorology, Elementary, Waldo, 80.
Mexico, Geological Institute, Bulletin, Aguilera, 422.
Michelson, A. A., relative motion of earth and ether, 475.
Mineralogy, Hintze, 251.
Naumann's, Zirkel, 424.
Minerals, determination by physical properties, Frazer, 162.
MINERALS—
Corundum deposits of Georgia, King, 489.
Diamonds, artificial production, Moissan, 243. Dundasite, Tasmania, 352.
Halite pseudomorphs, Hovey, 425. Heazlewoodite, Tasmania, 352.
Lawsonite, 489.
Northupite, artificial production, Schulten, 75.
Rœblingite. Franklin Furnace, N. J., 413.
Talc, St. Lawrence Co., N. Y., Smyth, 76.
Uraninite, gases from, 242.
Weldite, Tasmania, 352; Wellsite, Clay Co., North Carolina, 443.
Minks, A., die Protrophie, 355.
Minnesota, geology, vol. iii, part 2, 349.

N

Nagel, W. A., der Lichtsinn augenloser Tiere, 162.
National Museum, director appointed, 252.
Nehrling, H., N. American Birds, 358.
Neural terms, Wilder, 425.
Newton, Hubert Anson, Gibbs, 359.
Newton, H. A., worship of meteorites, 1.
Nichols, E. L., Outlines of Physics, 420.
Norske Nordhavs-Expedition, 1876–1878, 494.
North Carolina and its resources, 252.

O

Obituary—
Cope, E. D., 427.
Gould, B. A., 81.
James, J. F., 428.
Lea, M. C., 428.
Newton, H. A., 359.
Sylvester, J. J., 358.
Walker, F. A., 164.
Observatories, Mountain, Holden, 358.
Ostwald, W., Lehrbuch der Allgemeinen Chemie, 357.
Ostwald's Klassiker, 494.

P

Penck, Geogr. Abhandlungen, 492.
Penfield, S. L., rœblingite, Franklin Furnace, N. J., 413.
Perkins, C. A., Electricity and Magnetism, 246.
Petterd, W. F., Minerals of Tasmania, 352.
Physics, Outlines of, Nichols, 420.
Theoretical, Christiansen, 419.
Theory of, Ames, 420.
Pirsson, L. V., geology of Castle Mt. district, Montana, 250.
Pratt, J. H. wellsite, a new mineral, 443.
Precious Stones, production in 1895, Kunz, 352.

R

Rice, M. E., broadening of sodium lines, etc., 472.
Richards, T. W., spectra of argon, 15; multiple spectra of gases, 117; temperature and ohmic resistance of gases, 327; conductivity of electrolytes, 391.
Rocks—
Augite-andesite, Smyrna, Washington, 41.
Biotite-dacite, Pergamon, Washington, 47.
Diorite and gabbro, California, Lindgren, 312.
Granitic rocks, California, Lindgren, 301.
Granodiorite, California, Lindgren, 308.
Keratophyre dike near New Haven, Ct., Hovey, 287.
Rhyolitic lavas of South Mt., Penn., Bascom, 160.
supposed action of bacteria on, Branner, 438.
Rocks, Handbook of, Kemp, 76.
Treatise on, Merrill, 423.
Romanes, G. J., Essays by, 358.
Röntgen rays, Macintyre, 71, Kelvin, 152.
See *X-rays*.
Russell, I. C., geology of southwestern Washington, 246; "plasticity" of glacial ice, 344; glaciers of North America, 423.

S

Schneider, P. F., fault at Jamesville, N. Y., 458.
Scott, W. B., Introduction to Geology, 422.
See, T. J. J., Researches of the Evolution of Stellar Systems, 491.
Seiches on Bay of Fundy, Duff, 406.
Setchell, W. A., Laboratory Practice for Beginners in Botany, 490.
Smithsonian Physical Tables, Gray, 252.
Sodium lines, broadening in intense magnetic fields, Dunstan, Rice and Kraus, 472; Zeeman, 486.
Spectra of argon, 15; multiple, of gases, 117.
Spectrum waves, new formula, Balmers, 245.
Stellar Systems, Researches on the Evolution of, See 491.
Sun, temperature, Wilson and Gray, 152.

T

Tarr, R. S., Arctic Sea ice as a geological agent, 223; climate of Davis' and Baffin's Bay, 315; Elementary Geology, 351.

Taylor, F. B., scoured bowlders of the Mattawa Valley, 208.
Telephone, excursions of diaphragm, Barus, 219.
Thorp, F. H., Inorganic Chemical Preparations, 357.
Trowbridge, J., spectra of argon, 15; multiple spectra of gases, 117; temperature and ohmic resistance of gases, 327; does a vacuum conduct electricity? 343; electrical conductivity of the ether, 387; conductivity of electrolytes, 391.
Tutorial Statics, Briggs and Bryan, 426.

U

Ultra-red rays, Rubens and Trowbridge, 484.
Undulations, secondary, in Bay of Fundy, Duff, 406.
United States geol. survey report, 153, 249.

V

Velocity, means of producing a constant angular, Webster, 379.
Verrill, A. E., Ledidæ and Nuculidæ of N. Atlantic coast, 51; protective coloration in mammals, birds, etc., 132; changes in the colors of certain fishes, 135; supposed giant cephalopod on the Florida coast, 79, 162, 355.

W

Walcott, C. D., report of the United States geol. survey, 249; genus Lingulepis, 404.
Waldo, F., Elementary Meteorology, 80.
Walker, C. F., iodic acid in the analysis of iodides, 293.
Washington, H. S., igneous rocks from Smyrna and Pergamon, 41.
Webster, A. G., means of producing constant angular velocity, 379; rapid break for large currents, 383.
Weed, W. H., geology of Castle Mt. district, Montana, 250.
Wells, H. L., double halogen salts of cæsium and rubidium, 461; double fluorides of zirconium with lithium, etc., 466.
White, D., age of the lower coals of Missouri, 158.
Williams, H. S., Southern Devonian formations, 393.
Williams, R. P., Inorganic chemistry, 357.
Willis, J. C., Flowering Plants and Ferns, 343.
Wilson, E. B., the Cell in Development and Inheritance, 161.

X

X-rays, physiological effects, Sorel, 484.
of different penetrative values, Swinton, 484.
See *Röntgen rays*.

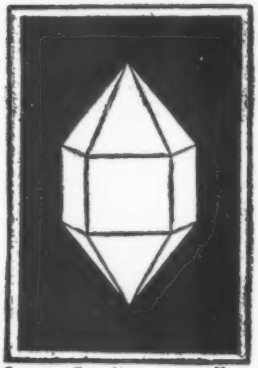
Z

Zirkel, F., Naumann's Mineralogy, 424.
Zoölogy—
Cephalopod of Florida, supposed, Verrill, 79, 162, 355.
Coloration, protective, in mammals, birds, etc., Verrill, 132.
Fishes, changes in the color of certain, Verrill, 135.
Glow beetle, light of, Muraoka, 151.
Ledidæ and Nuculidæ of N. Atlantic coast, Verrill and Bush, 51.

Roy Hopping,

123 LIBERTY STREET,

New York, U. S. A.



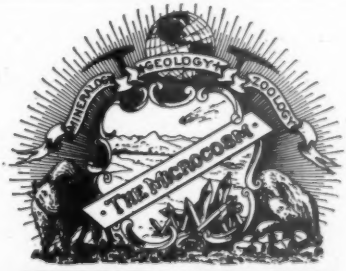
LOOSE CRYSTALS A SPECIALTY.

Free or detached. Perfect or nearly so.

Almandite, highly modified, Aragonite, simples and twins, Bilin; also sixlings, pseudohexagonal, Arsenic, **crystallized**, small spheres, Calcite, Joplin, rare points and English Butterfly-twins, Celestite, **acute form**, Cuprite, green, France, Dolomite var Teruelite, Spain, black, **tworhombs and base**, Fluroite green penetration twins, Magnetite, octahedrons and **parting** crystals, Hornblende, twins and simples, Bilin, Martite, Mica, emerald green, Microcline, green, Monazite and Xenotime, Olivine, new, Orthoclase, right and left Karlsbad twins, Phenakite, Phlogopite, large, Pinite, Pyrite, Pa rare ½ planes; Brazil, "iron cross" penetration twins; Quartz, black Spain, red, N. Mexico, dodecahedral, "lopsided," slim, striated, milky quartzoids, etc., Selenite, simples and "hour-glass phantom" twins, Staurolite, simples, oblique and right-cross twins, Titanite, wedge crystals, Canada, Swiss cruciform and arrow-head twins, Topaz, with base, brilliant, gemmy; Zircon, bright, mahogany brown, two pyramids, acute habit Fig. 6, Dana, new locality. **Prices 10c., 15c., 25c.,** rarely over except for extra fine examples. List free.

COLLECTIONS for beginners, students, high schools and universities at **$1, $5, $10, $50, $100.** Full lists, etc., in my new School Bulletin, 5 full page illustrations of crystal figures, etc., 6c.

CABINET SPECIMENS—Five cases from Austria, Hungary, France and Germany just received and numerous boxes from American localities have arrived recently. List of new arrivals on application.



SYSTEMATIC COLLECTIONS

For teaching MINERALOGY, GEOLOGY and ZOOLOGY a specialty. Reductions to suit the times on large collections purchased now.

RELIEF MAPS AND MODELS.

Almost the only place for correct and artistic work in this line. Send for list of 40 Relief Maps for Schools and Colleges. New Model of Southern New England just completed.

LANTERN SLIDES, CHARTS, ETC.

METEORITES.

A good price paid for all kinds. Have the best machinery for cutting and polishing. Have now on hand for sale about FOUR TONS OF METEORITES from 40 cents to $200 per lb. Among them are Cañon Diablo complete, 40 cents to $1.00 per pound. Polished and etched sections ¼ to 5 cents per gram.

	Per Gram.		Per Gram.
Toluca,	3 to 5 cents.	Fayette Co. (4),	3½ to 8 cents.
El Capitan (1),	10 to 25 "	Cross Roads (5),	$3.00
Cherokee (1),	20 to 40 "	New Concord,	7 to 12 "
Kendall Co.,	18 to 20 "	Winnebago,	8 to 20 "
Rockwood (2),	5 to 8 "	Beaver Creek (6),	25 "
Doña Inez (3),	10 to 15 "	Kessen,	15 "
Llano del Inca (3),	8 to 12 "	Pultusk,	18 to 15 "

(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci., Vol. 1. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894.

EDWIN E. HOWELL, 612 17th St., N. W., Washington, D. C.

COLLECTIONS OF THIN-SECTIONS FOR PRACTICAL MICROSCOPIC-PETROGRAPHICAL STUDY.

These collections contain thin sections of all the more important types of rocks as mentioned in the lately published (Stuttgart, 1896).

MICROSCOPIC PHYSIOGRAPHY OF ROCKS

By H. ROSENBUSCH, 3d edition.

To each one of them will be added a brief printed description of all the specimens and sections (by Prof. Dr. K. Busz, Münster) in order that the student himself may be able to recognize and determine the constituents of the rocks. For the present, three such collections will be provided.

1. *Collection of* 120 *thin sections in elegant case*, ... $38.00
   Together with the 120 specimens—size 8½ x 11cm, ... 63.00
2. *Collection of* 180 *thin sections in elegant case*, ... 56.00
   Together with the 180 specimens—size 8½ x 11cm, ... 98.00
3. *Collection of* 250 *thin sections in elegant case*, ... 81.00
   Together with the 250 specimens—size 8½ x 11cm, ... 144.00

ROCKS OF THE ODENWALD.

Complete collection of the most interesting rocks of the Odenwald Mts. in Germany, including all dike rocks (*Orbite, Luciite, Malchite, Beerbachite*, etc.) mentioned in the new Microscopic Physiography of Rocks by H. Rosenbusch, as well as metamorphic rocks, to which will be added a short description of their macroscopical and microscopical characteristics by Professor D. C. Chelius, of Darmstadt.

Collection of 100 *thin sections in elegant case*, ... $30.00
Together with the 100 specimens—size. 8½ x 11cm, ... 50.00

As all thin sections will be microscopically examined before being delivered, we can guarantee their perfect reliability and that they exhibit all the characters as mentioned in the above named descriptions.

NEW METEORITES!

Laborel, France—Chondrite, date of fall, 14, vi, 1870. Fragment with crust: 88 gr., $95.00: 3.5 gr., $5.00. Small fragments with and without crust, per 1 gr., $0.50 to $1.00

Lesves, Prov. Namur, Belgium—Chondrite, date of fall, 13, iv, 1896, fragments with crust, 125 gr., $170.00; 32 gr., $43.00; 2.6 gr., $6.00. Small fragments with crust, p. 1 gr., $2.50.

Zebrak (Praskoles), Bohemia—Chondrite, date of fall, 14, x, 1824. Fragment with crust, 51 gr., $107.00.

Beaconsfield, Victoria, Australia—Siderite, discovered 1896. Slices of various size, per 1 gr., $0.25. Detailed Price-List on application

NOVELTIES. Bismite, Broeggerite, Darapskite, Epididymite, Kainosite, Knopite, Leucophane cryst., Lorandite, Lossenite, Rathite, Salvadorite, Sulphoborite. Only FEW specimens.

Minerals and *fossils* in single specimens or in collections, bought or exchanged.

New editions of the following lists have come out and will be sent on demand:

Catalogue I^a: General catalogue of crystal models in wood, plate glass and paste-board, new crystallographical apparatus and instruments.

Supplements 1 and 2 to Catalogue IV; New Rocks.

Catalogue V^a: Professor Groth's collection of 396 crystal-models in wood.

Catalogue VIII^a: Prof. Hinke's student collection of 150 crystal-models in wood.

Catalogue XI: Prof. Vrba's Collection of 280 crystal-models in paste-board.

Catalogue XII: Professor Baumhauer's collection of 102 crystal-models in plate-glass.

List of new acquisitions of excellent fossils.

DR. F. KRANTZ,

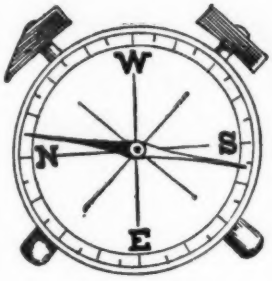
RHENISH MINERAL OFFICE,

BONN ON THE RHINE, GERMANY.

ESTABLISHED 1833.

Represented in the United States by Messrs. Eimer & Amend, 205-211 Third Avenue, New York.

MINERALS.



Among the many additions recently received in this department, we will note but a few. If there is anything you desire in the mineral line, write us, and your letters will receive prompt attention.

AWARUITE. Rounded grains of this rare nickeliferous iron (containing as much as 67.6 per cent. of nickel) in sand from New Zealand. **$1.00 to $5.00**

SILICEOUS INCRUSTATIONS on twigs, from Hot Springs district, New Zealand. **$0.25 to $1.50**

OPALS, Queensland, Australia, ranging in price from **$1.50 to $50.00**

CASSITERITE (Stream Tin). In large pebbles from New South Wales. **$0.75 to $1.50**

PISOLITIC LIMONITE of brick-red color, from Tern Island off coast of Queensland. (Polished sections.) **$0.50 to $6.00**

ITACOLUMITE (Flexible Sandstone), India, from 7 inches to 2 ft. 3 in. long. **$0.75 to $6.00**

URANOTHALLITE, Joachimsthal. **$2.00 to $5.00**

PHOSGENITE, Monte Poni. **$1.00 to $7.00**

VARISCITE, Utah. **$1.00 to $10.00**

WIRE SILVER, Freiberg, Saxony. **$0.25 to $5.00**

METEORITES.

We make a specialty of METEORITES. If you wish to purchase, or if you have meteorites to sell or cut, write us.

Send for our Special Catalogue of Meteorites, 80 pages, 24 illustrations, 25 cents.

Catalogue of Minerals, 168 pages, 25 Cents.

☞ Circulars sent on application, giving prices of the other 19 catalogues issued by us.

MINERALS SENT ON APPROVAL.

Ward's Natural Science Establishment,

18–28 COLLEGE AVE., ROCHESTER, N. Y.

A Dictionary of the Names of Minerals.

Historical and Philological. By A. H. Chester, Professor of Mineralogy, Rutgers College. 8vo, cloth, $3.50.

Notes on Assaying.

By P. De Peyster Ricketts, E.M., Ph.D., Edmund H. Miller, A.M., Ph.D. 8vo, cloth, $3.00.

Determinative Mineralogy and Blow-Pipe.

By Prof. George J. Brush. With an introduction on Blow-pipe Analysis by Professor S. E. Penfield, Sheffield Scientific School. 8vo, cloth, $3.50.

Cyanide Processes.

By E. B. Wilson, E.M. 12mo, cloth, $1.50.

The Chlorination Process.

By E. B. Wilson. 12mo, cloth, $1.50.

PUBLISHED BY

JOHN WILEY & SONS,

53 E. 10th St., New York City.

THE BLACK HILLS NATURAL HISTORY ESTABLISHMENT

OF L. W. STILWELL,

DEADWOOD, SOUTH DAKOTA, U. S. A.,

FOUNDED 1884,

Is prepared to furnish collectors, schools, museums, dealers at retail in collections or at wholesale with Minerals, Fossils, Ancient or Modern Indian Relics in great variety. Rare **Minerals** and **Rocks** characteristic of locality; 100,000 specimens. South Dakota and Wyoming vertebrate and invertebrate **Fossils** described by Professors Leidy, Marsh, Meek and others: Titanotherium, Brontotherium, Elotherium, Aceratherium, Diceratherium, Hyracodon, Oreodon, Miohippus, Hyopotamus, Agriocherus, Ammonites, Placenticeras, Scaphites, Nautilus, Baculites, Inoceramus, Prionocyclus, Heteroceras, Turrilites, Gasteropods, Fishes, etc., etc., Goniatites, Trilobites, Brachiopods, Crinoids, Corals, Fossil Plants, etc.

The largest and finest stock of Ancient Stone Relics now on sale in the United States, consisting of 10,000 Flint Arrow and Spear Heads of every type, from ½ to 9 inches in length, from many States. Spades, Hoes, Knives and Scrapers of flint 4 to 16 inches. Several thousand Stone Axes, Celts, Pestles, Mortars, Discoidals, Pipes, Bonner Stones, Plummets, Gorgets, Pendants, Amulets, Tubes, Ornaments and Ceremonials; also Hematites, Shell and Bone objects, and Copper Relics.

A large stock of Western Indian Beaded Buckskin work and weapons of the Sioux, Apaches, etc. Indian Photos, Alaska stereo. views of Totem Poles, etc. Photos of Black Hills scenery.

Send stamps for Catalogue of the line you are most interested in, and say in the letter whether you are a collector or regular dealer.

L. W. STILWELL,

DEADWOOD, SOUTH DAKOTA, U. S. A.

THE YALE REVIEW,

A QUARTERLY JOURNAL FOR THE SCIENTIFIC DISCUSSION OF ECONOMIC, POLITICAL AND SOCIAL QUESTIONS.

Published quarterly on the fifteenth of May, August, November and February. Under the able editorial management of

Professors HENRY W. FARNAM.
ARTHUR T. HADLEY,
JOHN C. SCHWAB,
EDWARD G. BOURNE,
W. F. BLACKMAN,
and IRVING FISHER.

"*Committed to no party, and to no school, but only to the advancement of sound learning, it aims to present the results of the most scientific and scholarly investigations in history and political science.*"

Valuable features of the REVIEW are the department of Notes and the Editorial Comment on the current and live topics of the day.

Subscription Rates, $3.00 per year, in advance.
Single numbers, 75 cents.

Sample copies sent free on application. To new subscribers back issues Vol. I to IV sent at $1.00 per volume unbound.

TUTTLE, MOREHOUSE & TAYLOR,
NEW HAVEN, CONN.

TUTTLE, MOREHOUSE & TAYLOR are also printers of Scientific Works and Works in Foreign Type, in German, Greek, Hebrew, Arabic, Syriac, Sanskrit; printers of Hebraica; The Yale Literary Magazine; Catalogues of Yale University; The American Journal of Science and Arts; Journal of the American Oriental Society: Transactions of the Conn. Academy of Arts and Sciences; Biographies, Genealogies and kindred Works.

THE PHILOSOPHICAL WORKS OF LEIBNITZ:

With notes by GEORGE MARTIN DUNCAN, Professor in Yale University. 400 pp. 8vo, bound in cloth, $2.50.

THE PHILOSOPHY OF KANT,

In Extracts. Selected by Prof. JOHN WATSON, LL.D., Professor in Queen's University, Kingston, Canada. 194 pp. 8vo, paper cover, 90 cents.

Above works sent postpaid on receipt of price.

PUBLISHED BY

TUTTLE, MOREHOUSE & TAYLOR,

NEW HAVEN, CONN.

TERRESTRIAL MAGNETISM

An International Quarterly Journal.

MARCH, 1897.

Responsible Editor:

L. A. BAUER, Assistant Professor at the University of Cincinnati.

"Magnus, magnes ipse est globus terrestris."—GILBERT, "De Magnete," 1600.

CONTENTS.

The Effect of Hardness on the Electrical and Magnetic Constants of Steel, with Particular Reference to the Tempering of the Magnetic Parts of Instruments, ... *Carl Barus.* 1

Vertical Earth-air Electric Currents, ... *L. A. Bauer.* 11

Magnetic Work at the Kew Observatory, ... *Charles Chree.* 23

On the Distribution of Magnetic Observatories over the Globe, *Adolph Schmidt.* 27

Results of Magnetic Observations on the Greenland Expedition of 1896, *G. R. Putnam.* 32

Letter to Editor: A Proposal with Regard to an International Magnetic Congress, ... *A. Schuster.* 35

Abstracts and Reviews: *C. Lagrange*, Is the Declination Independent of the Magnetic Moment of the Needle? F. E. NIPHER. *Van Rijckevorsel and van Bemmelen*, Observations Magnétiques en Suisse exécutées en 1895, P. W. The New Coast and Geodetic Survey Magnetometers. *C. A. Schott*, Secular Variation of the Earth's Magnetism in the United States. *E. D. Preston*, Magnetic Observations at High Altitudes, ... 37–42

Notes: Editorial Notice. Magnetische Landesaufnahme der Norddeutschen Gebiete Corrigenda, ... 43–44

THE EDITOR

CINCINNATI, OHIO.

THE UNIVERSITY OF CINCINNATI.

TWO DOLLARS A YEAR. SINGLE NUMBERS, 50 CENTS.

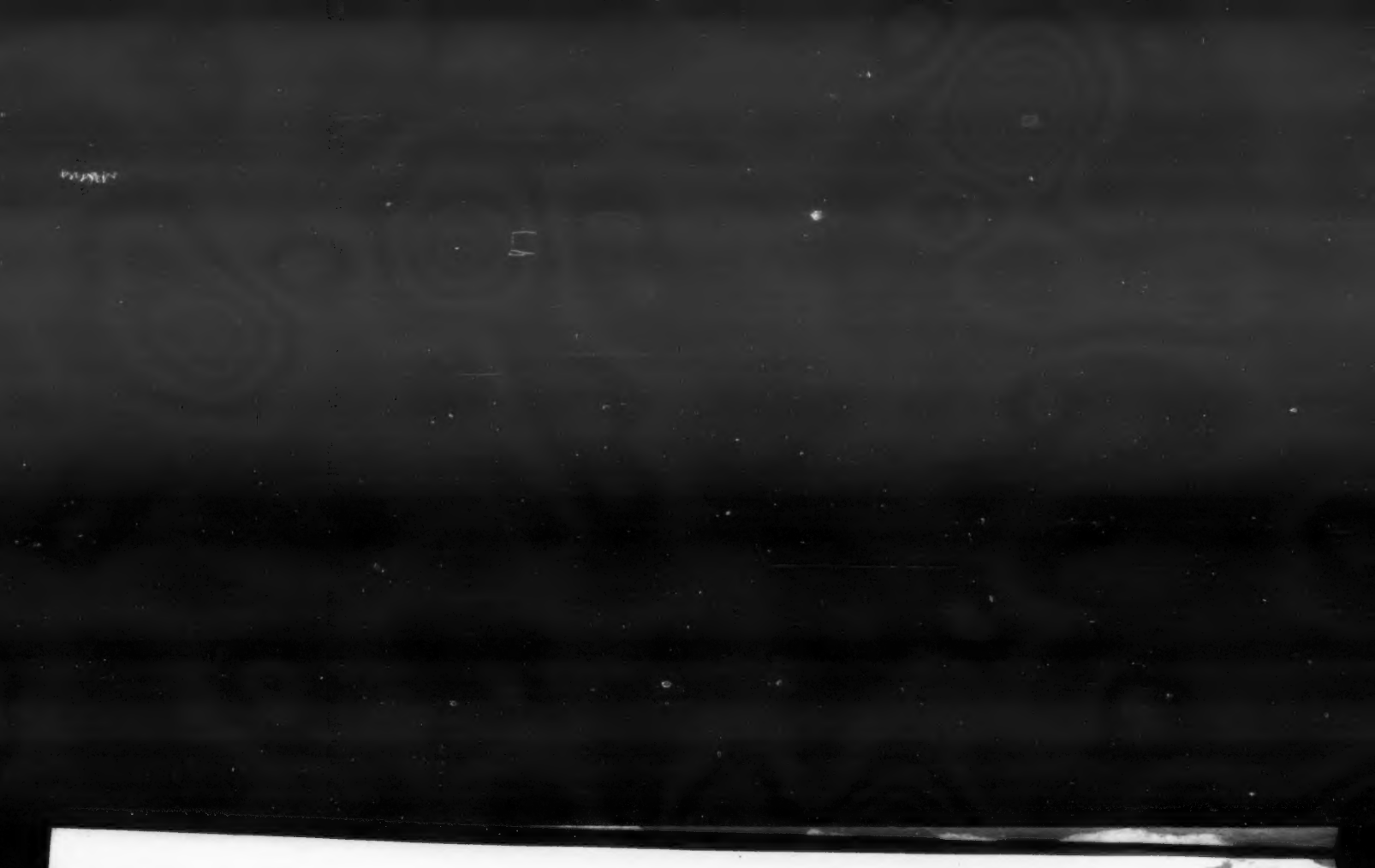
Foreign Subscription Price, Nine Shillings, Nine Marks, Eleven Francs.

WILLIAM WESLEY & SON,
28 Essex St., Strand,
London.

CURTS & JENNINGS,
(Cash Subscriptions)
220 West Fourth St., Cincinnati.

MAYER & MÜLLER,
Margrafen Str. 51,
Berlin.

Among the contributors to future numbers may be announced: Fleming (The Earth a Great Magnet), Abbe, Eschenhagen, Littlehales, van Bemmelen, McAdie, Schuster, Snellen, Stuport, Neumayer and others.



RUTILES! WONDERFUL RUTILES!

The old locality at Graves Mountain, Georgia, has recently changed hands and is now being actively worked. We have closed a contract which will secure to us every specimen found hereafter. Seven boxes have already arrived and the specimens will be placed on sale early in June. The grandeur of these Rutiles can scarcely be conceived. Their luster is wonderfully brilliant, the complexity of their twinning is amazing, while in size they are unequalled, one grand loose crystal being 3 × 4 × 5 inches and weighing five pounds, while there are others nearly as large. The many scores of matchless loose crystals and the large number of splendid matrix specimens make a collection of specimens such as was never before seen in any dealer's show-cases either in this country or abroad. The prices will be found most reasonable.

RARE SCANDINAVIAN MINERALS.

Cenosite ("Kainosite"), of which but a single, fragmentary specimen was ever before found, is now in our stock in most excellent little crystals on an attractive matrix of beautifully crystallized Magnetite and Diopside, at $2.50 to $10.00. **EPIDIDYMITE**, a new beryllium mineral, associated with *Eudidymite*, $5.00 to $15.00. *Apophyllite*, in groups of bladed crystals, $1.00 to $2.50. *Cleveite*, choice loose crystals, and small matrix specimens, $1.00 to $5.00.

GREENOCKITE ON CALCITE.

Large, fine crystals and groups of Calcite completely coated with canary-yellow Greenockite, 25c. to $5.00; from Joplin.

GOLDEN CALCITES.

Several hundred have been sold this month, but we are now unpacking some of the finest taken from the great cave, so that the display in our show-cases is as fine to-day as ever before. Calcites fromt his cave are *the finest in the world*, both in their matchless brilliancy and rich colors. Our present prices will surprise the most zealous bear. For further particulars see our **SPRING BULLETIN.**

MAGNIFICENT YELLOW WULFENITES!

Beautiful, showy groups of large-size crystals, 10c. to $10.00. We now have unquestionably the largest and best collection of yellow wulfenites ever brought together.

PHANTOM QUARTZ CRYSTALS.

Choice Quartz crystals of good cabinet sizes, with prominent chloritic phantoms, 25c. to $3.50.

MANY OTHER SPLENDID FINDS

Are mentioned in our recently issued **SPRING BULLETIN**, such as elegant *Arizona Descloizites and Vanadinites, Wulfenites, Quartz on Chrysocolla*, etc.; *New Mexican Turquois, Wolframite, Hematite*, etc. *California Stibnite; fine Utah minerals; Montana Covellite*, etc.

---

124 pp. ILLUSTRATED CATALOGUE, 25c. in paper; 50c. in cloth.
44 pp. ILLUSTRATED PRICE-LISTS, 4c.; 16 pp. Spring Bulletin free.

GEO. L. ENGLISH & CO., Mineralogists,
64 East 12th St., New York City.

CONTENTS.

Page.

ART. XLIII.—Studies in the Cyperaceæ; by T. HOLM 429

XLIV.—Bacteria and the Decomposition of Rocks; by J. C. BRANNER 438

XLV.—Wellsite, a new Mineral; by J. H. PRATT and H. W. FOOTE 443

XLVI.—Magnetic Increment of Rigidity in Strong Fields; by H. D. DAY 449

XLVII.—Geologic Fault in New York; by P. F. SCHNEIDER 458

XLVIII.—Certain Double Halogen Salts of Cæsium and Rubidium; by H. L. WELLS and H. W. FOOTE 461

XLIX.—Double Fluorides of Zirconium with Lithium, Sodium and Thallium; by H. L. WELLS and H. W. FOOTE 466

L.—Broadening of Sodium Lines by Intense Magnetic Fields; A. STC. DUNSTAN, M. E. RICE and C. A. KRAUS 472

LI.—Relative Motion of the Earth and the Ether; by A. A. MICHELSON 475

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics—Relation of Refraction to Density, TRAUBE: Properties of Free Hydrazine, DE BRUYN, 479.—Nitrogen Pentasulphide, MUTHMANN and CLEVER, 480.—Direct Union of Carbon and Hydrogen, BONE and JORDAN, 481.—Preparation of Rubidium and its Dioxide, ERDMANN and KÖTHNER: Pyrogenic Reactions of Aliphatic Hydrocarbons, HABER, 482.—Explosive Properties of Acetylene, BERTHELOT and VIEILLE: Form of the Atoms, C. FOURLINNIE, 483.—Use of rapid Electrical oscillations for determining dielectric constants, W. NERNST: Ultra-red rays, H. RUBENS and A. TROWBRIDGE: Production of X-rays of different penetrative values, A. A. C. SWINTON: Physiological effects of the X-rays, M. SOREL, 485.—Influence of magnetism on the nature of light emitted by a substance, P. ZEEMAN: First Principles of Natural Philosophy, A. E. DOLBEAR, 486.

Geology and Mineralogy—Congrès géologique international, 486.—Geological Survey of Canada, 488.—A guide to the fossil invertebrates and plants in the department of geology and palæontology in the British Museum: Sea mills of Cephalonia, F. W. CROSBY and W. O. CROSBY: Geologischer Wegweiser durch das Dresdner Elbthalgebiet zwischen Meissen und Tetschen: Lawsonite: Preliminary report on the Corundum deposits of Georgia, 489.

Botany—Practical Botany for Beginners, F. O. BOWER: Guide to the Study of Common Plants, an Introduction to Botany. V. M. SPALDING: Elements of Botany, F. DARWIN: Laboratory Practice for Beginners in Botany, W. A. SETCHELL: Lessons in Elementary Botany for Secondary Schools, T. H. MACBRIDE, 490.

Miscellaneous Scientific Intelligence—Researches on the Evolution of Stellar Systems T. J. J. SEE, 491.—Annals of the Astronomical Observatory of Harvard College: Geographische Abhandlungen. A. PENCK, 492.—Beiträge zur Geophysik: Zeitschrift für physikalische Erdkunde, G. GERLAND: Lavori esequiti nell' Instituto di Fisica dell' Università di Pisa, H. BATTELLI: Ostwald's Klassiker der exakten Wissenschaften: La cause première d'après les données expérimentales, É. FERRIÈRE: Den Norske Nordhavs-Expedition, 494.

INDEX TO VOL. III, 495.